DEVELOPMENT OF COST BENEFIT ANALYSIS MODEL OF ACCIDENT PREVENTION ON CONSTRUCTION PROJECTS

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This work or any part thereof has not previously been presented in any form to the University or to any other body whether for the purpose of assessment, publication or for any other purpose (unless other wise indicated). Save for any express acknowledgements, references and/or bibliographies cited in the work, I confirm that the intellectual contents of the work are the result of my own efforts and no other person.

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Date………………………………….

Abstract

The Health and Safety Executive estimated the annual cost to British employers and other duty holders failing to comply with health and safety requirements to be up to £18 billion. It is estimated that the construction industry contributed £2billion of these appalling statistics. To date, health and safety management is still perceived as being costly and counterproductive in the construction industry. This research investigated the net benefit of accident prevention and explored the relationship between preventative costs and these benefits, with a view to drawing attention to the economic consequences of effective/ineffective management of health and safety by contractors in the UK construction industry. The need to investigate the cost of accident prevention in relation to overall benefits of accident prevention is therefore deemed necessary. A quantitative research methodology was employed in investigating these costs and benefits within the UK construction industry. From the ratio analysis small contractors spend relatively higher proportions of their turnover in total on accident prevention than medium and large contractors, and medium contractors spend a higher proportion of their turnover in total on accident prevention than large contractors. The results also show that medium and small contractors gain relatively higher proportions of their turnover in total as benefits of accident prevention than large contractors. The benefits of accident prevention far outweigh the costs of accident prevention by a ratio approximately 3:1. The relationships between these costs and benefits were examined. The costs of accident prevention were found to be positively and significantly ($P < 0.005$) associated with benefits of accident prevention. These associations were modelled using simple linear regression, and from these models it can be inferred from the results that the more contractors spend on accident prevention the more they derive benefits of accident prevention, which would improve health and safety performance on construction sites.

The developed model was subsequently validated using experts and practitioners opinion from the UK construction industry. This developed model should provide good guidance to assist contractors in developing effective and efficient health and safety management for UK construction industry.

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DEDICATION

This research is dedicated to my late father Mr Ikpe Igwu, My late mother Mrs Alami Igwu, my brothers, Godwin Oyine Ikpe, Inalegwu Ikpe, Aboje Ikpe and children, my sisters Enalami Ikpe, Onyanji Ikpe, Ugboga Ikpe and children and finally my beloved son Master Ikpe Godwin Ikpe who firmly stood by me.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

This chapter, which is an overview of the thesis, presents the research background and context of the study. The justification, scope of the research and the main research questions are posed. Subsequently, the aim and objectives are presented followed by a summary of the research methodology adopted. Thereafter, a statement of the contribution to knowledge and the limitations of the study are described. The chapter concludes with an explanation of the organisation of the thesis including sub-themes under each chapter.

1.2 BACKGROUND TO THE STUDY

The construction sector is defined as one which embraces the construction materials and products; suppliers and producers; building services manufacturers; providers and installers; contractors, sub contractors, professionals, advisors and construction clients and those organisations that are relevant to the design, build, operation and refurbishment of buildings (DTI, 2007 now BERR). Construction is hugely important to the UK economy. The industry represents some 10% of the Gross Domestic Product (GDP) and employs 2.2 million people with output at £104 billion (HSE, 2005; Ferret and Hughes, 2007; BERR, 2008).

The figures quoted above are significant, and underline the industry's real importance. This industry is concerned with the provision of the country's essential infrastructure and 'backbone'. Based on the standard industry classification (SIC, 2007) this essential infrastructure includes: water, roads, bridges, airports as well as buildings including schools, hospital retail developments and housing, which are all designed and produced by the construction industry. Although in the delivery of these projects, the UK construction industry has developed a world wide reputation for quality, it has also been noted that it remains one of the most dangerous industries in the UK (Ferret and Hughes, 2007). To be able to compete with the best in the world market, to attract the best talent, and to have an attractive image and reputation, the well being of the industry is essential (HSE, 2004). For this reason, it is incumbent on employers and other duty holders to ensure that the health and safety and general well-being of workers within the industry are safeguarded at all times.

Unfortunately, it has been established that employers and other duty holders are failing to comply with their health and safety obligations. The consequence of this as established by health and safety data from the HSE is that the construction industry contributes more than any other industry to the estimated £18 billion total economic cost each year to the UK for health and safety failure (HSE, 2004). Pearce (2003) estimated this economic and social cost to be in the region of £2 billion for the construction industry alone. This suggests, therefore, that there is huge scope for making substantial savings by investing more in health and safety (HSE, 2003).

The construction industry is regarded as a hazardous and high-risk environment where workers face a greater risk of work-related fatality or injury than workers in other industries. Though the industry has been paying significantly greater attention to health and safety in recent years with the aim of reducing accidents and injuries, it is consistently responsible for the largest number of fatal work injuries than any industry in the UK (HSE, 2007). Based on an average of the past five years, construction fatalities accounted for around 30% of all worker deaths (HSE, 2007). In the last 25 years, over 2800 people died from injuries from construction work and many more were injured or made ill (HSE, 2007). On the basis of these statistics, it has been established that construction has the second worst industry record for health and safety next to agriculture (Bomel, 2001).

By any relevant measure, construction is a not a safe industry (Everett *et al*. 1996; Gyi *et al*. 1996), and as a result has gained an unenviable reputation in relation to the health, safety and welfare of its workers (Egan, 1998; Bomel, 2001; HSE, 2005). Injuries and facilities on construction sites are a major problem. To highlight the scale of this problem, close scrutiny of the health and safety performance of the industry over recent years is necessary.

1.2.1 Health and Safety Performance of the Construction Industry

Table 1.1 and Figure 1.1 shows the accident occurrence in the UK construction industry from 2000/01-2006/07 (seven consecutive years). These figures confirm the need for significant improvement in health and safety performance in the construction industry. According to Edwards & Nicholas (2001) construction industry accident figures have remained consistently high, whereas the accident figures for other industry sections have steadily declined. This trend indicates that additional measures must be introduced to reduce the rate of accidents and subsequently help improve health and safety performance.

As can be seen from Table 1.1, the number of fatal injuries fell from 105 in 2000/01 to 59 in 2005/06 (one of the lowest for the industry) but rose by 23.4% to 77 in 2006/07, evidence that whilst significant improvement has been made through the various initiatives implemented over the years, these initiatives may still not be adequate in the effort to secure accident free working environments. The 23.4% increase in 2006/07 is particularly worrying. Indeed, it can be argued that even the loss of one life is one too many and, therefore, current accident levels and the resulting fatalities are still too high. Major injuries fell from 4708 (in 2000/01) to 4,430 (in 2006/07) representing an overall decline of about 6%, and over-three-day injury also fell from 9796 to 8299 (15%), which suggests some improvement on non-fatal injuries. However, it can be argued that this improvement is not considerable enough to conclude that safe working environments have been achieved across the industry. Indeed in both major and over-three-day injuries, there appears to be stagnation or even marginal increases in the level of accidents in the last two years of the survey shown in Table 1.1 and Figure 1.1.

Table 1.1: HSE (2007) Statistics of Fatal, Major and Over-3-day Injuries in the UK Construction Industry

Year	2000/01	01/02	02/03	03/04	04/05	05/06	06/07
Fatal injuries	105	80	70	71	72	59	77
Annual Δ%	-	- 24%	- 12.5%	1.4%	1.4%	- 22%	23.4%
Major injuries	4708	4595	4720	4728	4486	4472	4430
Annual Δ%	-	- 2.4%	2.7%	0.2%	- 5%	- 0.3%	-1%
Over-3-day injuries	9796	9695	9578	8995	8250	8291	8299
Annual Δ%	-	- 1%	- 1%	- 6%	- 8%	0.5%	0.1%

Source: HSE (2007)

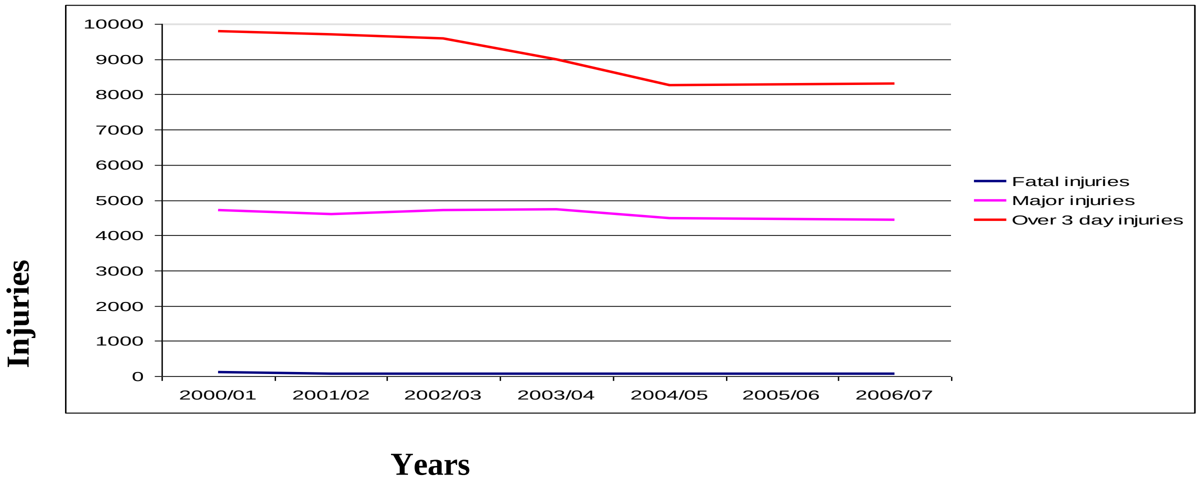

Figure 1.1 Accident Trends from 2000/01 to 2006/07
Source: HSE (2007)

Together with the significant upturn in fatalities (23.4% in 2006/07), these statistics are all the more surprising when all the stringent health and safety requirements imposed on the industry over recent years by the HSE are considered. Clearly the statistics reinforced the consensus that there is a need to improve health and safety performance in the construction industry. Regardless of the hazardous or high-risk nature of construction, all accidents are not only foreseeable but also preventable (Ferret and Hughes, 2007), and it is unethical and illegal for employers to place their employees and others at unreasonable risk (Booth *et al*. 2005).

The foregoing not withstanding, the accident trends highlighted raise interesting questions of whether health and safety regulations are being enforced adequately enough by the oversight bodies, whether contractors have found loopholes in the regulations which allow them to avoid their health and safety obligations, whether contractors are just becoming complacent, whether contractors are consciously compromising health and safety measures, whether the workers themselves and their attitudes and actions make accidents unavoidable or whether the hazardous nature of construction is such that accidents are inevitable (cf. Ferret and Hughes, 2007). These are all important issues bordering on why accidents occur, and need to be explored through further in-depth research.

When accidents do occur however, they not only tarnish the image of the industry and make it difficult to attract skilled labour, but more importantly from a business perspective, they tend to be very expensive. Accidents can give rise to serious costs and have major financial impact particularly on small and medium construction companies (Lancaster *et al*. 2003). Apart from the pains and discomfort to workers and their families and friends as well as their colleagues, death and permanent disability, accident costs can also be quantified in terms of the financial losses to contractors. These costs can be classified as either direct costs or indirect costs (Oxenburg and Marlow, 2005) which together place a large economic burden on contractors, clients and society.

1.2.2 Direct Costs of Accidents

Direct cost is the actual costs that can be directly attributable to injuries and fatalities (HSE, 2004; Tang *et al.* 2004). It refers to expenditure when accidents occur including insurance; damage to buildings and equipments or vehicles; damage to the product; expenditure on medical care; cost of investigation; legal costs; death; permanent disability; worker illness; losses of current production; pains as well as discomfort associated with accidents (Everrett *et al*. 1996; Tang *et al.* 2004; Oxenburg and Marlow, 2005; HSE, 2006; Ferret and Hughes, 2007).

An estimate of the direct cost to employers of accidents in construction projects has been provided by Fellows *et al.* (2002) and was calculated as £433.22 per employee per annum as shown in Table 1.2.

Table 1.2: Direct Costs of Accidents to Employers

Predicted accident rates	Category	Actual number	Loss	Value (£)
1	Reported accident. Loss to Company: 200% of wage rate	33	33 X 20 days = 660 days lost per 1,000 workers at 200% = 1,320 days at £70 per day	92,400
10	Minor accidents	330	330 X 2 hours = 660 hours lost per 1,000 workers = 73 days at 200% = 146 days at £70 per day	10,220
33	Property damage Insurance costs	990	990 x £300 20p per £100 wages for 1,000 workers 0.2 x 16,800 x1000 100	297,000 33,600
Total cost per 1,000 employees				433.220
Cost per employee (per annum)				433.22

Source: Fellow *et al.* (2002)

Although the basis of this calculation and the assumptions on which it is based can be challenged, (for instance its assumption of an accident rate of 33 accidents per 1000 workers), this figure is instructive and provides some idea of the scale of the problem. To put this into proper context, and using the same accident rate of 33 accidents per 1000 workers used by Fellows *et al*. a small contractor employing up to thirty employees is likely to have one accident per annum and will incur a cost of £12,996.60 per annum (30 x £433.22). It should be noted that this is a conservative figure as observed by *Fellows et al.* (2002) in the original calculations and could be much higher.

1.2.3 Indirect Costs of Accidents

Indirect costs refer to costs that may not be covered by insurance and are the less tangible costs that result from accidents (Ferret and Hughes, 2007). They are those costs incurred by the diversion of time to deal with the consequences of an accident, and can also affect productivity. These indirect costs include: cleaning up; hire costs of temporary equipment; waste disposal; temporary labour; costs of advising and consulting experts; lost time, sick pay, overtime working and temporary labour; and; loss of business reputation (Everrett *et al.* 1996; Tang *et al*. 2004; Oxenburg and Marlow, 2005; HSE, 2006; Ferret and Hughes, 2007). It has been claimed by several authors that most of the company costs are those stemming from the indirect costs of accidents (production losses) (cf. Lindqvist and Lindholm, 2001; Fellow *et al.* 2002; Ferret and Hughes, 2007). According to Fellow *et al.* (2002) indirect costs are up to four times higher than direct costs of accidents. Indeed, Ferret and Hughes (2007) estimate that indirect costs are up to 36 times higher than direct costs of accidents. Based on the illustrative calculation of £12,996.60 per annum direct costs in the preceding subsection, indirect costs could potentially range from £51,986.40 (4 x £12,996.60) to

£467,877.60 (36 x £12,996.60). Clearly, it can be argued that accident costs of this magnitude will have significant impact on the bottom line of construction firms, especially small contractors whose turnover is less than £5m (DTI, 2007).

Given that most construction companies operate and compete on very small profit margins (Lindqvist and Lindholm, 2001), such costs are likely to affect their financial health. Each time an accident occurs, the total cost of the injury or illness and additional expenses, such as insurance premiums, must be subtracted from profits in real income (Lanoie and Tevanes, 1996).

1.2.4 Other Costs of Accidents

The above discussions have focused on accidents as they affect employers. However, it is important to recognise that accidents affect not only the employer but all the key stakeholders of the construction industry. In the first instance, the workers who are involved in the accident are those most directly affected by the accidents. The result may be death, injury or illness, which cost workers their present and extended health. By extension, it affects their families as well.

As demonstrated in Figure 1.2, which highlights the principal stakeholders affected; accidents in the construction industry also have great consequences for co-workers and the society as a whole. Table 1.3 further gives a brief overview of effects of costs accidents affected by stake holders. However, as the principal or direct driver of health and safety policy on construction projects, and those most commonly held accountable for accidents on construction sites, the costs to employers (more commonly referred to as contractors) are usually at the fore of all discussions on the cost of accidents. Employers or contractors, therefore, also remain the focus of this research.

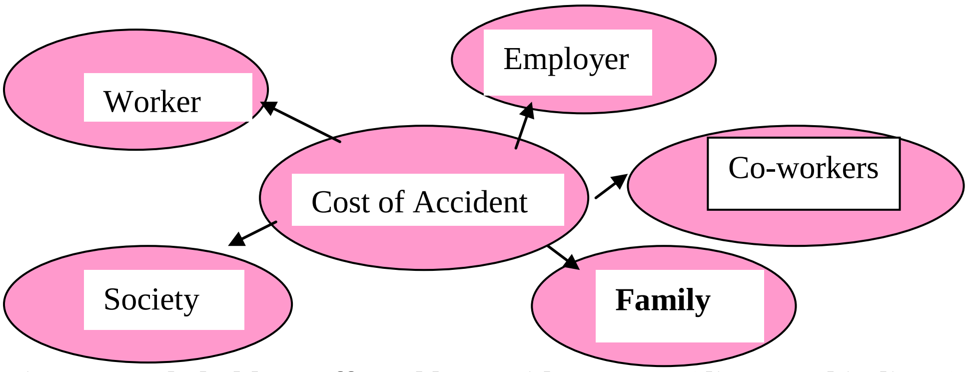

Fig. 1.2: Stakeholders Affected by Accident Costs (direct and indirect)

Developed from HSE (2006)

Table 1.3 below gives further explanation of costs of accidents as affected by stake holders

Table1.3: Costs of Accidents as Affected by Stakeholders

Stakeholders	Non-tangible	Tangible
Worker	Pain and suffering, moral and psychological suffering (especially in the case of death and permanent disability)	Loss of salary, reduction of professional capacity; loss of time (medical treatment); site compliance of health and safety issues.
Family and friends of the affected worker	Moral and psychological suffering, medical and family burden	Financial loss; extra costs; loss of time to take care of the injured worker.
Co-workers	Bad feeling, worry or panic (in case of serious or frequent accidents)	Loss of time, increase of workload; training of temporary staff
Employer	Bad reputation; litigation cost; insurance cost; compensation cost	Decrease in production,; damages to machinery; equipment, and material; quality losses; recruitment and training of new staff; increase of production costs,; increase of insurance premium; administrative costs; litigation costs and absenteeism.
Society	Reduction of the human labour potential; reduction of the quality of life.	Loss of production, increase of social costs, medical treatment and rehabilitation costs, decrease of standard of living.

Developed from HSE (2006); Ferret and Hughes (2007)

1.3 JUSTIFICATION OF THE RESEARCH

The foregoing discussions have highlighted the significance of the UK construction industry, the extent of accidents within this industry and the effects of these accidents. The conclusion drawn from these discussions are that given the significance of the construction industry, the level of accidents and their costs are too high and, therefore, there is a need for improvement in health and safety management. There is a lot of support for this conclusion in the literature (c.f Edward & Nicholas, 2001) and the HSE has for instance demonstrated that improved health and safety management can prevent 70% of accidents on site (Kheni *et al.* 2005). To ensure success, any efforts aimed at improving health and safety must be underpinned by sound research. In this regard, a lot of research has been undertaken to provide sound empirical and theoretical platforms on which health and safety initiatives can be formulated and implemented. Some examples of these research studies within the construction context include Everret *et al.* (1996) which explored costs of accidents and injuries; Hinze *et al*. (1998) which looked at causes of construction injuries; Tang *et al.* (2004), which looked at social safety investment; Oxenburg and Marlow (2005) which investigated the costs of accidents direct and indirect costs of injuries; and Cameron and Duff (2007), which examined the potential for employing goal setting with safety performance measurement and feedback to improve management of safety performance. Other initiatives aimed at providing a systematic basis for improving health and safety management include HSE's development of online interactive tools for contractors (HSE, 2005), and the introduction of health and safety laws like the Construction Design and Management Regulation (CDM) 1994 and 2007.

As shown by the examples of research highlighted in the preceding paragraph, these past efforts to support accident reduction on construction sites have focused predominantly on causes and costs of accidents, as well as some of the management techniques that can be used to improve safety behaviour. Given the response from business surveys, which indicate that 10% of UK businesses would be more inclined to do more for health and safety management if they were provided with evidence that business benefits would arise from better health and safety management (Wright *et al*. 2001 as cited in Shearn, 2003), it can be argued that the dimension of benefits, which has been largely overlooked in past research, represents another key frontier in research where health and safety knowledge can be improved.

If construction businesses are more likely to do more for health and safety management if the benefits of accident prevention are brought to their awareness, then there is no logical reason why a gap in knowledge on the benefits of accident prevention should exist. Therefore, to help bridge this gap in knowledge it is considered appropriate to undertake research to throw light on the business benefits that can be derived from accident prevention. A useful framework that facilitates the investigation of benefits within the context of the costs expended to secure those benefits is the cost benefit analysis (CBA) framework. Although this approach has been applied in many other contexts (cf. Lanoie and Tavenas, 1996; Lindqvist and Lindholm, 2001), it is yet to be applied within the context of the construction industry in the UK to highlight the relationship between preventative costs of health and safety and the benefits that flow from such costs. CBA, therefore, offers a fresh approach for exploring health and safety within the UK construction industry, and offers a systematic framework for shedding light on the business benefits that can be derived from accident prevention through better health and safety management. It is against this background that this research undertakes to shed new light on health and safety management by applying the CBA approach as a fresh perspective for exploring the benefits that can be derived from accident prevention within the UK construction industry from a contractor's perspective.

The adoption of CBA provides an opportunity to bring to the attention of contractors, the financial benefits of improving construction health and safety through the implementation of appropriate measures. This approach should provide decision-makers within construction firms with valuable insight leading to better decision-making in relation to health and safety and improved health and safety performance on construction sites. This will be by way of exposing not just the real costs of accident prevention, but also the business benefits, which currently are unclear.

1.4 AIM AND OBJECTIVES OF THE STUDY

The aim of the research is, therefore, to develop a CBA model of accident prevention on construction projects by investigating the costs and benefits of accident prevention and to explore the relationship between preventative costs and these benefits, with a view to drawing attention to the economic consequences of effective/ineffective management of health and safety by contractors in the UK construction industry**.**

To achieve this aim the following objectives are to be pursued.

1. Critically review literature on UK construction health and safety including statistics and legislation to contextualise the health and safety problems of the

construction industry and to establish from a theoretical perspective the cost and benefit of accident prevention elements that need to be considered when investigating accident prevention;

2. Critically review the principles of cost benefit analysis (CBA) and to make a case for its applicability to the construction health and safety context;
3. Develop a CBA conceptual framework of accident prevention that captures the benefits of accident prevention and contrasts these with the costs of accident prevention, to show the potential for achieving an overall benefit;
4. Collect relevant data from health and safety practitioners and professionals in the UK construction industry on costs and benefits of accident prevention to test the conceptual framework;
5. Employ appropriate statistical analysis with a view to exploring the relationship between costs and benefits of accident prevention;
6. Develop a CBA model that relates costs of accident prevention with benefits of accident prevention;
7. Test, refine and validate the model towards its predictive accuracy and potential relevance for practical application of the regression model.

1.5 RESEARCH QUESTIONS

From the aim and objectives stated above, the key research questions that need to be addressed in the study are as follows:

- What impact do costs of accident prevention have on benefits of accident prevention to contractors?

- Can the CBA approach help to demonstrate to stakeholders that the cost of accident prevention can be offset by the benefits accruing from accident prevention?
- Do the benefits of accident prevention outweigh the associated costs of accident prevention in the construction industry?
- What is the correlation between costs and benefits of accident prevention?
- Will greater expenditure on accident prevention improve safety performance on construction sites, and yield greater benefits to contractors?

To address these keys research questions, the following methodological approach is adopted.

1.6 RESEARCH METHODOLOGY

The research methodology is largely quantitative. Such approach implied that the study presumes that the "truth" is a measurable fact that exists in the real world and that quantitative dimensions of accident prevention costs and benefits can be objectively and independently be measured using specific quantitative methods and frameworks (Creswell, 2003). A quantitative approach to this study was considered appropriate to determine the quantitative nature of the relationship between the costs and the benefits of accident prevention. Evidence from the literature on similar studies also supports the adoption of a quantitative approach (see Tang *et al.* 2004; Everret *et al.* 1996 & Oxeburg and Marrow, 2005). Elements of qualitative approach were also incorporated to provide alternative insight into the costs of accident prevention and benefits of accident prevention. The study commenced with a literature review, which provided an opportunity to develop an appropriate theoretical framework for the study. Subsequently, a questionnaire was developed and a postal questionnaire survey was used in eliciting the main data and also in validating aspects of the findings relating to the potential relevance of the recommended application of the model.

The sample for the survey was drawn from the population of UK contractors. In keeping with the theoretical position of the study (see chapter 4), quantitative measures of the costs of accident prevention and benefits of accident prevention were derived from the data generated from the field survey and tested on the CBA framework of accident prevention. The research paradigm adopted enabled statistical tools such as correlation analysis and regression analysis to be used in the interpretation of the data and discussion of the findings. The details of the qualitative and quantitative research methodologies employed including their philosophical underpinning are more fully discussed in Chapter 5.

1.7 CONTRIBUTION TO KNOWLEDGE

An original contribution to knowledge is an important concern in any doctoral research (Walker, 1997). The problem is that the concept of originality could be arbitrary (Fellows and Liu, 1997). Walker (1997) has documented various ways to demonstrate originality such as development of new methodologies, tools and/or techniques, new areas of research, new interpretation of existing material, and new application of existing theories to new areas or a new blend of ideas. Drawing on this background, the contribution to knowledge of this research could be viewed in respect of its immediate contribution and what potential it may have in the future if further work is carried out.

It was observed from the review of literature that a comprehensive CBA model of accident prevention in the UK construction industry is yet to be developed for the use of contractors. Whilst extensive research studies on health and safety in the construction industry have been undertaken, it would appear that no effort has focused on the application of CBA to highlight and bring to the awareness of both practitioners and researchers the potential benefits that can be derived from expenditure on accident prevention in the UK construction industry. By focusing on this particular gap, this study is building on the existing knowledge on construction health and safety management, and opening up a new area of research through the application of an existing technique to a new area. This, therefore, represents a significant contribution to knowledge by this research. Through the development of a model showing the relationships between the costs of accident prevention and benefits that accrue from these costs, this research offers a tool which could be applied by practitioners and researchers to systematically capture cost outlays on accident prevention and use that as a basis for predicting the potential benefits of accident prevention. It is envisaged that the benefits from this research work will be wide-ranging as the findings have the potential to be used by many construction stakeholders. These findings will help different stakeholders in the industry to make appropriate decisions, take suitable measures, and devote the necessary resources required for accident prevention on construction projects.

1.8 LIMITATIONS OF THE STUDY

As with all survey based research there are bound to be limitations, which need to be acknowledged. Given that the focus of this research was entirely on the UK construction industry, it is entirely plausible that there may be significant differences in the findings if this study is replicated in another jurisdiction. Thus, even though the findings could serve some useful lessons given the similarities in other countries, it may not be applicable to other countries. Indeed, this aspect is recommended as a potential area for further research in the construction industries of other countries. Secondly, it is not possible to guarantee the veracity of the responses even though attempts have been made to minimize the potential for wrong responses by ensuring that questionnaires were only sent out to health and safety managers who should have access to the information required. Thirdly, questionnaire surveys are notorious for poor response rates especially in construction industry. Even though various measures were implemented in accordance with Creswell's (2003) recommendations to maximize the response rate, the same challenge was experienced in this research.

The limitations noted here do not, however, undermine the validity of the research undertaken and its main findings. It should be remembered that scientific research is a never-ending quest aimed at the understanding of some phenomenon which requires continuous measurement and examination of associations (Babbie, 1990), and this research is just one step on this quest.

1.9 OUTLINE OF THESIS CHAPTERS

The thesis consists of nine (9) chapters. Chapter 1 outlines the context within which the research is undertaken and the justification for the research, and then sets out the aim and objectives. The key research questions are posed and the research methodology to address these questions is outlined. The key contribution to knowledge of the research and the key limitations are discussed.

Chapter 2 presents a critical review of the literature focusing on the causes and costs of accidents in the UK construction industry, measures to prevent accidents, the costs of accident prevention, as well as accident costs and benefits of accident prevention. Critically, the review also focuses on health and safety legislation and how it affects accident prevention and costs.

Chapter 3 present a critical review of the CBA literature. The chapter traces how the use of CBA has developed and its theoretical underpinnings, and then investigates how it has been applied in various other contexts. It then explored how this technique may be adapted for application in the construction health and safety context. The justification for applying this technique in the UK construction industry context is re-emphasised.

In order to investigate costs and benefits, it is necessary to have a conceptual framework that brings together, in a logical manner, all the essential aspects to be investigated, and provides appropriate parameters and points of reference for the investigation. In Chapter 4, the discussion addresses the development of a CBA conceptual framework of accident prevention. This aids the identification of appropriate hypotheses, data collection and subsequent hypotheses testing.

In Chapter 5, a detailed outline of the research methodology adopted for undertaking this research is presented; in this case a quantitative research methodology. Arguments are presented justifying this choice of approach and the specific research methods applied to collect data. The data collection process is detailed in this chapter.

Chapter 6 presents the first part of the data analysis. The purpose of this analysis is to make it possible to specify the kinds of construction organisations which the inferences drawn from this research are applicable, and the contexts within which they operate. The chapter further presents ratio analysis of the data on costs and benefits of accident prevention and gives an overview of the trends within the sample in relation to the general costs and benefits of accident prevention within the UK construction industry. Further evaluation to identify differences in the costs and benefits of accidents prevention across different categories of contractors is also presented.

Chapter 7 is devoted exclusively to the development of the substantive model relating costs of accident prevention and the benefits accruing from such costs. Pearson's correlation coefficients, regression analyses, analysis of variance (ANOVA), multicollinearity tests, and residual analyses are employed in the development of the model. It concludes with discussions of the findings and the potential recommended applications.

Chapter 8 provides the results of the validation of the CBA model. The Chapter describes the validation process, which includes both external and internal validation. Experienced practitioners were invited to share their opinions on the findings. Their views are reported within this chapter.

Chapter 9 presents the conclusions and recommendations drawn from the entire study. Here the objectives and research questions are reassessed and highlighted. Major conclusions drawn from the research and future areas of research are also presented. The chapter concludes with recommendations for construction industry practitioners, and recommendations for future research.

1.10 SUMMARY

This chapter has briefly outlined the context within which the research is undertaken and the justification for the research. Through the discussions it has been established that the rates of accidents in the UK construction industry are relatively high and that there is a need for more research to provide insight into this problem and help reduce the rates of accident. It has also been shown that whilst there has been a lot of research on the causes and costs of accidents in construction, there is scope to explore the benefits side of accident prevention, which has largely remained unexplored. It is argued that CBA provides an appropriate platform for exploring the benefits alongside the costs of accident prevention. On the basis of this the aim and objectives are set out, and the key research questions are posed. The research methodology to address these questions is then outlined, and the contribution of the study to knowledge is briefly stated together with the limitations of the study. Chapter 1 has, thus, laid the foundation for the thesis. On this foundation, the thesis proceeds with the detailed discussion of the research. The next chapter, (i.e. chapter 2) introduces a critical review of construction health and safety management.

CHAPTER 2

CONSTRUCTION HEALTH AND SAFETY: A REVIEW

2.1 INTRODUCTION

This chapter presents a critical review of the literature on UK construction health and safety that establishes from a theoretical perspective, the cost and benefit elements that need to be considered when investigating accidents. The chapter also addresses the first key objective of this research which sought to critically review the literature on health and safety management with the view to understanding the factors militating against accident prevention. The literature review approach is adopted to cover the causes and costs of accident prevention and legal issues affecting the UK construction industry. Thus, various strands of the literature starting with definition of health and safety, accidents causation, accident prevention, costs of accident prevention, and benefits of accident prevention are brought together as well as the health and safety legislation to identify research gaps in the investigation of accident prevention and its impact on construction industry.

Fellow et al. (2002) points to a moral and economic necessity to maintain safe working practices on the construction site. Yet the construction sector seems to be overly prone to health and safety failures (refer to chapter 1 page 4 section 1.2). It is against this background that the legal, economic and moral aspects of health and safety in construction are discussed.

2.2 DEFINING HEALTH, SAFETY AND ACCIDENT

Prior to reviewing the literature, it is necessary to define key terminologies. "*Health is defined as the protection of the bodies and minds of people from illness resulting from materials, processes or procedures used in the workplace while safety is defined as the protection of people from physical injury"* (HSE, 2006; Ferret and Hughes, 2007). According to Ferret and Hughes (2007), the borderline between health and safety is ill-defined and the two words are normally used together to indicate concern for the physical and mental well-being of the individual at the work place. HSE (2006) defined health and safety *as "about preventing people from being harmed or killed at work"*. Harm may be caused through accident at work place. HSE (2006); Ferret and Hughes (2007) defined accident as *"an unplanned event that results in injury or ill health of people, or damage or loss to property, plant, material or the environment or a loss of a business opportunity"*. There are different types of accidents in the construction industry. HSE (2006); Ferret and Hughes (2007) classified accidents in the construction industry as fatal and non-fatal (major and minor injury). These accidents are foreseeable and preventable (Ferret and Hughes, 2007). In order to prevent these accidents, it is therefore, necessary to understand what causes these accidents in the construction industry.

2.3 ACCIDENT CAUSATION IN THE CONSTRUCTION INDUSTRY

Gyi *et al.* (1996); Abdelhamid and Everrett (2000); HSE (2004); Ferret and Hughes, 2007) identify the causes of accident as the results of unsafe acts activities and conditions. Abdelhamid and Everett (2000) attribute the unsafe conditions to four main causes; management action/inaction, unsafe acts of workers/co workers, events not directly human related and unsafe conditions. Abdelhamid and Everret (2000) referred these unsafe acts and unsafe conditions as immediate or primary causes of accident. The unsafe acts, unsafe conditions and management related factors are shown in Table 2.1. These causes of accident on construction sites as shown in Table 2.1 may lead to serious costs for a contractor (Lancaster *et al*. 2003). For instance, HSE (2005) demonstrated that accident affects productivity rates, increase insurance costs and may lead to legal action against the firm. Apart from its effect on costs for a contractor, accidents may also lead to health implications for a worker such as musculoskeletal injury, vibration, dermatitis, radiation diseases, and skin borne infections, respiratory problems, asbestosis, eye problems, hearing damage, heat stress, cold stress, decompression illness and psychological stress (Gyi *et al*. 1996). Kartam (1997) reinforces this argument that accident also causes many human tragedies, demotivates construction workers, disrupts construction processes, delays progress and adversely affects the reputation of the construction industry. On the bases of these arguments, it has therefore, been established that the causes of accident may lead to cost that can definitely impact the efficiency and effectiveness of construction operation.

Table 2.1 Causes of Accident on Construction Sites

Unsafe Acts	Unsafe Conditions	Management related causes
Failure to use or wear PPE	Inadequate or missing guards	Inadequate planning
Failure to warn others of danger	Missing platform guardrails	Inadequate design
Leaving equipment in a dangerous condition	Defective tools and equipment	Lack of training and awareness
Using defective equipment	Inadequate fire warning system	Lack of communication
Using equipment in a wrong way	Contact with electricity	Inadequate supervision
Contact with moving machinery	Acts of violence and noise	Ineffective policy of the management
Struck by moving vehicle	Fire hazards	Failure to comply with operating instructions
Struck by moving including flying/falling object;	Hazardous atmospheric conditions	
Strike against something fixed or stationary	Excessive noise	
Manual handling	Not enough light to see to do work	
Failure to lift loads correctly	Exposure to an explosion	
Trapped by something collapsing or overturning;	Dust	
Taking alcohol or drugs on construction site;	Contact with harmful substance	
Lifting or carrying		
Slip trip or fall on same level		
Fall from a height		
Working without authority		

Source: (Gyi *et al.* 1996; Abdelhamid and Everret, 2000; Bomel, 2001; Holt, 2001; HSE, 2004; Ferret and Hughes, 2007)

It is therefore, suggested that a proper understanding of these causes of accident is critical to the development of appropriate health and safety management that will reduce the causes and consequently accidents and costs. When causes are understood, preventive procedures have a greater probability of being effective (Hinze and Russell, 1995) as cited in (Manase, 2008). Although various researchers have tried to find out the causes and costs of accidents and how these accidents can be prevented in the construction industry, the construction sector seems to be still overly prone to health and safety failures. The rate of accidents as shown in Table 1.2 page 4 through the data collected by HSE provide a compelling justification to search for improved methods of reducing the causes and costs of accidents. The next section critically reviews some of the construction health and safety researches that have been undertaken to reduce accidents on construction sites.

2.4 ANALYSIS OF CONSTRUCTION HEALTH AND SAFETY RESEARCH

Despite the introduction of various measures to reduce accidents on sites such as CDM Regulations 1994 and 2007, limitations still exist. The limitations are reflected in the number of construction accident occurrences as captured in the data collected by HSE (see chapter 1 section 1.2 page 4). These limitations prompted the initiation of various research works that were undertaken aimed at understanding the causes of construction accidents and in the process developed diverse health and safety theories and models aimed at reducing the causes and costs of accidents. Some of these research studies undertaken are discussed below.

Abdelhamid and Everret (2000) evaluated root causes of construction accidents in the United States and suggested that unsafe conditions resulted from management action/inaction, unsafe acts of workers/co-workers, and unsafe conditions that form a natural part of the construction site. Abdelhamid and Everret (2000) asserted that the uniqueness of the construction industry dictates the need to tailor many of the contemporary accident causation models of human error theories. It was in this regard that they introduced a model known as Accident Root Causes Training Model (ARCTM) tailored to the needs of the construction industry. The ARCTM attempted to direct the attention of the investigations to the conditions that existed at the time of the accident and antecedent human behaviour. The ARCTM was designed to guide the investigator through a series of questions and possible answers to identify a root cause of accident, to investigate how the root cause developed and how it could be eliminated.

However, other researchers have had misgivings about ARCTM as having not sufficiently addressed the real root causes of accidents. For example, Gibb *et al*. (2001) pointed out that this model focused on three possible issues to consider as corrective actions namely, worker training, worker attitude and management procedures. Gibb *et al.* (2001) further argued that the importance of the project concept and design as not causes of accidents was not implied in ARCTM. Prior to this in 1996, Gibb and Foster had argued that accidents might occur because of improper storage of materials and tools accompanied by carelessness on the part of workers. In support of this argument, Morris and Wilcocks (1996) also attributed accident causation in the construction industry to workers. It was argued that the workers have a duty to take reasonable care for their own safety and that of other people who might be affected by their actions or omissions. However, it can be argued that this concept is misguided because it places the burden of accident prevention alone on workers, which makes any efforts to prevent accidents fundamentally unreliable and uncontrollable. The worker alone does not contribute to causes of accident in the construction industry. A number of important contributions have been made in support of this argument, with Holt (2001) for instance arguing that the causes of accident can be controlled by management.

Whittington *et al.* (1992) explored the issue of accident causation and concluded that poor management decision making and inadequate management control are the major contributors to many accidents in the construction industry. Haslam *et al.* (2004) reinforces this argument that accidents are caused by management shortcomings as well as technical deficiency. In support of this argument, Cameron and Duff (2007) demonstrated that management actions can differentiate safe sites from unsafe sites based on the observed level of safety management commitment. Moreover, HSE (2003) had argued that employers have the responsibility to provide a safe working environment for their employees. From these arguments, it can be established that the root causes of accidents are often related to the management system, which may be due to management policies, procedures, supervision, effectiveness and training. For instance, management may fail to provide proper or adequate personal protective equipment (PPE). In addition, management may also fail to provide the training needed to keep their workforce up to date. Thus, it can be summarised that while active workers participation is vital for delivering effective health and safety management, it is the responsibility of management, given the control they have over organisational resources, to define the culture and the strategy and commit the resources required to help prevent accidents on construction sites. Strong commitment is required in this regards (Aston, 1998).

Levitt and Samelson (1987) developed Standard Accident Cost Accounting System and defined it as a management system which increases supervisory accountability for safety performance by immediately measuring and highlighting accident costs. The system was developed to provide contractors with a method for tracking accident costs along with other costs in each project. The system was designed to make accident costs visible to all levels of management. It was used as a way of establishing accountability and created an attitude that safety is a line responsibility rather than top management and staff responsibility. This system developed by Levitt and Samelson (1987) simplified the accounting for and tracking of accidents and also helped to identify trends so that management would be able to pinpoint problems and develop better solutions. Whilst the benefits of such a system are fairly obvious, it can be argued that the developed system can not be effective in reducing accidents because it only increases management awareness of accident costs and line responsibility for safety. However, there is limitation in the system developed by Levitt and Samelson, the system fails to make benefits of accident prevention (e.g. savings in insurance cost, saving in compensation claims, saving in medical expenses, saving in production losses) visible to all levels of management, which can convince them to spend more on accident prevention. Therefore, the system, can not guide management in their decision making to reduce costs of accident and improve health and safety performance in the construction industry.

Hinze (1990) observed that within the traditional construction process, little or no provision is usually made for the cost of health and safety measures. Hinze (1990) further observed that whilst clients have to pay for construction work, there were no specific cost provisions for construction safety, except in highly sensitive projects. Although it is expected that contractors will price for health and safety in their tenders, it is also well established that contractors typically underpriced tenders to be competitive. Consequently, aspects such as health and safety suffer (cf. Mayhen and Quirlan, 1997; Fabiano *et al.* 2004). Thus, Hinze's (1990) research study provides some evidence that investment in health and safety measures has been neglected in the past, and this has had a significant impact on safety management in the context of construction operation and performance. This insight provided by Hinze indicated that health and safety measures were not given due emphasis. In the UK, the Health and Safety at Work Act (HSWA) 1974, which also applies to the construction industry, makes it compulsory for employers, employees, and designers to take reasonable care of the safety and health of others. In addition, contractors are required under different Regulations (e.g. CDM 2007) to ensure that health and safety measures such as provision of first aid facilities, PPE, safety promotion safety training are in place for the purpose of accident prevention

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As illustrated in the preceding discussions, past efforts in construction industry research have usually focussed on identifying causes and cost of accidents in an attempt to reduce accident. To date there has not been much research in the area of quantifying the costs and benefits of accident prevention. Although these previous costing studies have added valuable insight into different causes and costs of accident, they have largely been conducted with no specific focus on benefit of accident prevention on construction project. This research would be directed in the area of quantifying the costs and benefits of accident prevention to offer a practical guide to the contractor in order to spend more on accident prevention on construction sites.

The question arises as to why contractors have not been motivated to invest more into health and safety measures to generate more benefits. Philosophically, there is nothing new about moral and legal elements in the overall accident prevention efforts. Previous researches as illustrated above show that health and safety in the UK construction have tended to emphasis management of health and safety to reduce accidents. While causes and costs of accident have been emphasised, the economic benefits have been neglected. Having discussed the causes of accidents, it is necessary to review costs of accidents in the construction industry.

2.5 COSTS CAUSED BY ACCIDENTS

Accidents generally, affect production and often lead to substantial losses to contractors (HSE, 2006). Different types of costs (both direct and indirect) that are associated with accidents occurrence were discussed in chapter 1 section 1.2.2 and 1.2.3 and are further shown in Table 2.2. It was stated in chapter 1 that the impacts of these costs of accidents have implications on contractors. It has also adverse effects on workers such as social cost (e.g. death, pains and discomfort, permanent disability) that are difficult to express in monetary terms and economic cost (e.g. loss of output, insurance cost) (Haslam *et al*. 2004; Booth *et al.* 2005).

Table 2.2: Direct and Indirect Costs of Accident

Direct costs	Indirect costs
Insurance premium	Hire costs of temporary labour
Litigation cost	Lost time of other employees due to accidents
Medical expenses	Cleaning/waste disposal
Material damaged	Working day lost
Compensation claim	Sick pay
Accident investigation	Overtime working due to accidents
Death	
Permanent disability	
Pains and discomfort	

Source: Ferret and Hughes (2007); HSE (2006)

Coble and Blatter, (1999) suggested that the prevention of accident causes may lead to reduction in costs caused by accident and ultimately lead to benefits. A significant challenge for contractors is to prevent accident in the construction industry to reduce these costs caused by accident (Lanoie & Tavenas, 1996).

2.6 ACCIDENT PREVENTION

Accident prevention begins with having a clear understanding of those factors that may play key roles in their causation (Hinze *et al.* 1997). As noted previously in section 2.4, management play a key role in accident prevention. According to Ferret and Hughes (2007), without the commitment of the management, there can not be effective implementation of health and safety measures. Management provides the motivation and resources to deal effectively with workplace accidents (OSHA, 1989; Kartan, 1997). Mitropoulos *et al.* (2004) pointed out that cost pressure may prevent management from providing the required health and safety measures. However, Lancaster *et al.* (2003) had argued that if required health and safety measures are provided, it can bring economic benefits to contractors. This therefore, shows that there is a business case to be made through research to bring the economic benefits of accident prevention to the attention of contractors. It is suggested that if economic benefits of accident prevention are brought to the attention of the management, they will be more motivated to take necessary steps, which will make accident prevention more realisable. Apart from economic benefits to contractors, it will also prevent social costs (Carcoba, 2005).

In relation to the above factors to prevent accidents, companies develop different strategies/policies which affect the level of emphasis and resource allocation across various factors. Company strategies/policies are influenced by variety of factors. Within industry, Lancaster *et al.* (2003) have identified the factors influencing a company's approach to health and safety management and the principal factors are summarised in Figure 2.1.

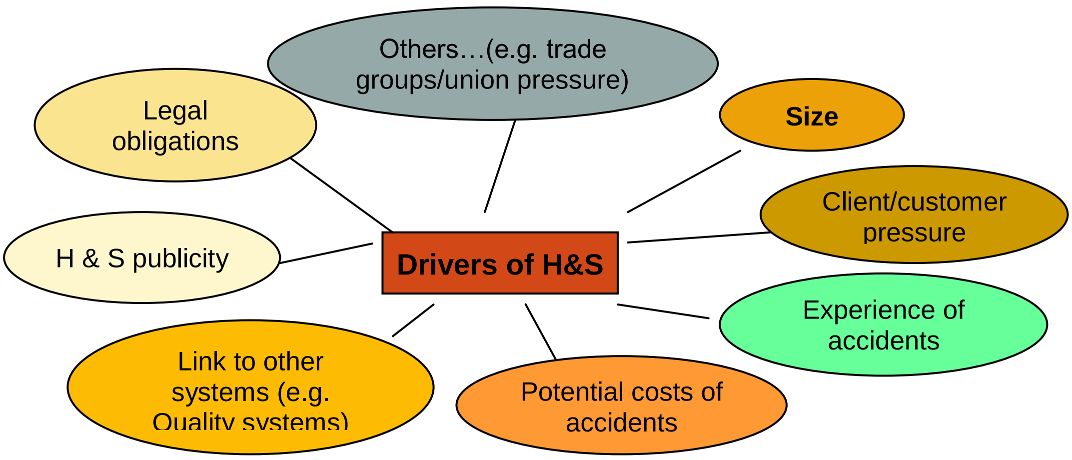

Fig. 2.1: Factors Influencing Construction Health and Safety Measures

Source: Developed from Lancaster *et al.* (2003)

These factors identified by Lancaster *et al*. (2003) cut across all industries. However, the manner in which they reflect in construction health and safety management are summarised in Table 2.3 and discussed in detail below.

Table 2.3: Factors Influencing Construction Health and Safety Measures

Factors	**Cost implications or Impacts**
Legal obligations	Fear of persecution, cost of compliance
Health and safety publicity	Image and creditability; criteria for prequalification
Link to other systems	quality, reliability and competitiveness
Potential costs	direct and indirect costs of accidents
Experience of accidents	Increases awareness and appreciation of hazard and risks
Client/customer pressure	Potential for future contracts
Size of organisation	Safety personnel and structures to manage health and safety capital available to invest in health and safety
Other factors(e.g. trade groups/union pressure)	Working rule agreements. Information supplied by design team, involvement of contractor at design stage

Source: Developed from Levitt and Samelson (1987); Lancaster *et al*. (2003); Ferret and Hudges (2007)

2.6.1 Legal obligations

There are various pieces of legislation, which govern health and safety law (Smith *et al.* 1983) however, the HSWA1974 which most of legislation are derived from and the European Community Act 1972 which supersedes the UK health and safety laws are discussed below.

- The Health and Safety at Work Act 1974.

- The European Community Act 1972

2.6. 1.1 The Health and Safety at Work Act 1974 (HSWA)

HSWA 1974 is the most important piece of legislation dealing with health and safety, which applies to every type of work situation including construction (Ferret and Hughes, 2007). The Act resulted from the findings of the Robens Report, published in 1972 and sets out general duties for the health and safety of those involved in work including employers, employees, self-employed and suppliers. Smith *et al*. (1983) revealed that the HSWA 1974 has two features as follows:

1. It is an enabling Act and sets the overall framework and philosophy within which detailed legislation (Regulations) sits.
2. It is referred to as ‘goal setting’ rather than ‘prescriptive’.

According to Smith *et al.* (1983), one of the principal objectives of the HSWA 1974 is to involve everybody at the work place to create awareness of the importance of achieving high standards of health and safety and the primary responsibility for doing what is necessary to avoid accidents to the construction industry. The HSWA 1974 applies to the construction industry and makes it compulsory for employers, employees, and designers to take reasonable care of the safety and health of others. However, the HSWA 1974 did not specify the quality of health and safety measures to be implemented. For example, type of PPE and quality of training to undertake. It can be argued, that contractors with the knowledge of these loopholes can compromise health and safety measures on construction sites to their own advantages, which may have a serious impact on effective application of health and safety measures.

The HSE was established as a result of the requirement set by the HSWA 1974. It has a statutory responsibility to make adequate arrangements for the enforcement of health and safety law. This is done by understanding a range of activities such as inspecting workplaces, conducting research, investigating accidents and complaints, issuing guidance and providing advice. It is also the responsibility of the HSE under the HWSA 1974 to ensure that measures are in place to facilitate the reporting and recording of work-related accidents, diseases and dangerous occurrence. The Reporting of Injuries Diseases and Dangerous Occurrence Regulation 1995 (RIDDOR) are the regulations that require that all work-related accidents, diseases, and dangerous occurrences in the UK be reported to the HSE.

In summary, the HSWA 1974 introduced a legal obligation which was subsequently expressed in regulations which contractors must comply with to prevent accidents on sites. These Regulations and the health and safety measures they gave rise to are summarised in Table 2.4

Table 2.4 Health and Safety Legislation Affecting Health and Safety Measures

Title	Summary	First aid	PPE	Promotion	Training	Safety personnel	General
Health and Safety at Work etc Act 1974	General duties to ensure health and safety of employees and others so far as is reasonably practicable	✓	✓	✓	✓	✓	✓
Electricity at Work Regulations 1989	Control of exposure of electricity						✓
Construction (Head Protection) Regulations 1989	Ensuring head protection is provided and worn		✓				✓
Workplace (Health, Safety and Welfare) Regulations 1992	General workplace issues, including some design requirements for commercial buildings	✓					✓
Construction (Health, Safety and Welfare) Regulations 1996	Previous regulations about practical safety requirements on site-replaced by these and the Work at Height Regulations						✓
Fall (Regulations). The HSWA Regulations 1996	Deal with the prevention of falls on the level at a height.		✓				
Confined spaces Regulation 1997	Safe working in confined spaces						✓
Training (Regulation 28) at Work Regulations 1998.	Provision of training for persons carrying out construction work.				✓	✓	
Personal Protective Equipment at Work Regulations 1998	Provision and use of personal protective equipment		✓				
Provision and Use of Work Equipment Regulations 1998	Machinery, vehicle and other work equipment suitability and safety including safety helmets		✓		✓	✓	
Management of Health and Safety at Work Regulations 1999	General management of health and safety including availability of health and safety advice and risk assessment			✓		✓	
Construction, Design and Management) Regulations 2007	Make it compulsory for employers, employees, and designers to take reasonable care of the safety and health of others	✓	✓	✓	✓	✓	✓

Source: Developed from HSE (2006)

2.6.1.2 The European Community Act 1972

The European community (EC) law has a force in the UK construction health and safety legislation by virtue of the provision of the EC Act 1972 (Smith *et al.* 1983). The EC law supersedes the UK law should there be any conflict arising and was introduced as part of obligations by member states to 'pay particular' attention to encouraging improvements, especially in the working environment, as regards the health and safety of workers.

The HSE in implementing the Directives of the EU in the UK is required to propose regulations (Neal and Wright, 1992; Stranks, 1999). In response to a Directive of the European Union in 1992, the Construction (Design and Management) Regulations 1994 (CDM) was introduced by the UK government to reduce accidents on construction sites. However, the HSE observed that the CDM Regulations 1994 were not effective enough and did not meet the expectations of accident reduction. Consequently, the CDM Regulations was modified and the updated regulations came into force in 2007.

2.6.1.3 The CDM Regulations 2007

The CDM Regulations 2007 was introduced to integrate health and safety into management of the project and to encourage everyone involved to work together. It replaced the CDM Regulations 1994 and the Construction (Health, Safety and welfare) Regulations 1996. The HSE produced an Approved Code of Practice (ACOP) that provides guidance on compliance with the new Regulations. For all intents and purposes, the ACOP is part of the CDM Regulations as a court may treat failure to comply with the code as evidence of breach of the relevant provisions of the Regulations.

As indicated previously, the main state agency responsible for enforcing the regulations is the HSE. But in respect of construction work on rail projects; the Office of Rail Regulation (ORR) is the enforcing authority while local authorities are responsible for health and safety breaches in premises such as offices, hotels, retail centres, and places of entertainment. The major requirement of the CDM 2007 Regulations is that a co-ordinator must be appointed before any other appointment. According to the HSE (2006), the appointment of a co-ordinator before design work begins makes it possible to:

- advise clients on the competence and resource of their appointees;
- notify HSE about the project; ensure that design work and early planning is properly co-ordinated;
- develop effective management arrangements for the project;
- locate the information needed for designers and contractors and advise the client if surveys need to be communicated to fill significant gaps;
- advise the client on the suitability of the initial construction phase plan;
- produce or update a relevant user friendly, health and safety file suitable for future use at the end of the construction phase.

The Regulations impose specific duties on all project participants who are referred to as duty holders. The responsibilities of these duty holders are summarised in Table 2.5.

Table 2.5: Duty Holders and their Function under CDM Regulations. 2007

Duty holder	Description of duties	Description of duties
Clients	• Check competence of all appointees; • Ensure there are suitable management for the project; • select and appoint a competent CDM coordinator and principal contractor; • Be satisfied that the CDM coordinator and principal contractor are competent and will allocate adequate; resources for health and safety; • provide the CDM coordinator with information relevant to health and safety on the project.	• Appoint co-ordinator and ensure job done properly; • Appoint principal contractor; • Provide information; • Make sure that the contraction phase does not start unless there are suitable: welfare facilities and construction phase plan; • Retain and provide access to the health and safety file (* There must be a co-ordinator and principal contractor until the end of the construction phase); • Ensure construction work does not start until the principal contractor has prepared a satisfactory construction phase plan (health and safety plan); • Ensure the health and safety file (section 3.1.2) is available for inspection, after the project is completed. (Retain and provide access to the health and safety file).
Co-ordinator	• notify details of the project to HSE; • co-ordinate health and safety aspects of design work and cooperate with others involved with the project; • facilitate good communication between the client, designers and contractors.	• Advice and assist the client with his/her duties; • Co-ordinate design work; • Liaise with principal contractor; • Prepare/update health and safety file; • liaise with principal contractor regarding ongoing design work; • advise and assist the client with his/her duties as a client under CD 2007; • Identify, collect and pass on pre-construction information.
Designers	• Eliminate hazards and reduce risks due to design; • consider during the development of designs the hazards and risks which may arise to those constructing and maintaining the structure; • design to avoid risks to health and safety so far as is reasonably practicable; • reduce risks at source if avoidance is not possible; • consider measures which will protect all workers if neither avoidance nor reduction to a safe level is possible; • ensure that the design includes adequate information on health and safety.	• Check client is aware of duties and co-ordinator has been appointed • Client HSE has been notified; • Provide any information needed for the health and safety file; • pass relevant information on to the CDM coordinator so that it can be included in the construction phase plan (health and safety plan); • co-operate with the CDM coordinator and, where necessary, other designers involved in the project; and • provide relevant information with the design about remaining risks aspects of the design of the structure or its construction or maintenance, as will adequately assist clients, other designers, and contractors to comply with their duties under the Regulations; • alert clients to their duties and that a CDM co-ordinator has been appointed.

Principal contractor	• plan, manage and monitor the construction phase in liaison with contractor; • prepare, develop and implement a written plan and site rules (Initial plan completed before the construction phase begins); • draw up and implement the construction phase health and safety plan; • give contractors relevant parts of the plan; • liaise with CDM co-ordinator regarding ongoing design; • ensure that there are adequate welfare facilities are provided for those working on the site from the start and maintained throughout the construction phase; • draw up and implement the site rules as necessary.	• Check competence of all appointees; • Ensure all workers have site inductions and further information and training needed for the work; • Consult with the workers; • Liaise with co-ordinator re ongoing design; • Secure the site; • provide a suitable site induction and ensure that those working on site have received the training that they need to carry out the work safely and without risks to health; • ensure the site is suitably fenced and prevent unauthorised people from entering the site (Secure the site); • ensure that there is co-operation between those working on the site, and that work is co-ordinated in such a way as to prevent danger; • ensure that there are suitable arrangements for effective consultation with the workforce; • make sure that the right health and safety information is provided to the right people at the right time; • make sure suitable welfare facilities are available.
Contractors	• Plan, manage and monitor own work and that of workers; • Check competence of all appointees and workers; • Train own employees; • Ensure there are adequate welfare facilities for their workers; • co-operate with the principal contractor in planning and managing work, including reasonable directions and site rules.	• Co-operate with principal contractor in planning and managing work, including reasonable directions and site rules; • Provide any information needed for the health and safety file; • Inform principal contractor of problems with the plan; • Inform principal contractor of reportable accidents and dangerous occurrences; • inform the principal contractor of any problems with the plan; • provide information when self-employed act as contractors for the health and safety file; • Provide information to their workers.
Every employee	• Check own competency; • Report obvious risks; • Comply with requirements and other regulations for any work under their control; • be entitled to information about health and safety during the construction phase.	• co-operate with others and co-ordinate work so as to ensure the health and safety of construction workers and others who may be affected by the work; • report obvious risks; • Co-operate with others involved in the project.

Source: Adapted from the HSE (2007)

2.6.1.4 Health and Safety Plan

The health and safety plan forms the basis of the health and safety management structure. Being part of the tender documents (Joyce, 2001), it should: indicate (in general terms) the approach to health and safety to be adopted by everyone; identify the main health and safety hazards likely to occur to employees, self-employed and the public; specify precautions to be taken; require work to be done to recognise technical standards and in accordance with published guidance.

2.6.1.5 Health and Safety File

The health and safety file provides information for clients, designers, co-ordinators, contractors and others involved in carrying out construction work on the health and safety issues concerning the project (Joyce, 2001). The information include: adequate information about any aspect of the project or structure or materials, which might affect the health and safety of any person carrying out construction work. The health and safety file is made available by the CDM coordinator to the client at the end of the construction phase work for future guidance on health and safety issues.

2.6.2 Health and Safety Publicity

Negative health and safety publicity adversely affects the image of contractors. Since image drives business in construction, contractors can be motivated to take action to avoid negative publicity about health and safety.

2.6.3 Link to other Systems

According to Warrack and Smith (1999), total quality management strategies result in increased quality, reliability and competitiveness, while also satisfying legislative requirements for safety. Tam *et al.* (2000) also considered safety under the quality system, and suggested that a comprehensive documentation system forces contractors to take a proactive view of safety management. From these arguments, it can be inferred that the introduction of other systems, in particular quality systems, can influence the health and safety orientation of a contractor.

2.6.4 Potential Costs

The concern of potential costs of accidents, both direct and indirect (see chapter 1 and section 2.5), have great impacts on a contractor's bottom line through inter alia compensation claims, and insurance premiums. It is evident that these costs will be incurred whenever an accident occurs on a project and these costs can be quit dramatic (Everrett *et al.* 1996). These costs can be reduced by aggressive safety management (Levitt and Samelson, 1987). The concern of potential cost implications on their business can motivate contractors to prevent accidents. The potential costs may also extend beyond the contractors. For instance, the UK government may incur accident costs through loss of revenue and tax because improvement in construction industry leads to more tax as a result of increased profitability (HSE, 2005).

2.6.5 Experience of Accidents

Contractors' experience of accidents influences their awareness of the hazards, risks and impacts of accidents. Thus, it can be expected that the more experience of accidents a contractor has had, the greater their awareness of the impacts. Consequently, they are more likely and willing to be motivated to take action to prevent accident than those contractors with less experience.

2.6.6 Client/Customer Pressure

Client /customer pressure have significant impact on health and safety in construction industry (Lancaster *et al.* 2003). Under the CDM regulations, clients are required to appoint competent contractors to perform their duties and they are to properly fund health and safety issues (HSE, 2006; Ferret and Hughes, 2007). The regulation requires that contractors must have certain health and safety standards in place to be able to procure and carry out their work. Contractor's performance in terms of health and safety management therefore, has great legal implications for the client. Consequently, contractors' health and safety records are often used as key prequalification criteria and a poor health and safety record could impact negatively on the ability of contractor to secure future contracts. Such pressure generated by the requirement for clients to employ competent contractors can translate into more effective health and safety policies from contractors.

2.6.7 Size of Organisation

Generally, there are three main categories of contractors' when classified by size. These are small, medium and large contractors (Lancaster *et al.* 2003; DTI, 2005). The Department of Trade and Industry (DTI, 2005) now known as the Department for Business Enterprise & Regulatory Reform (BERR) categorised organisation size as small (< 50), medium (50 - 249) and large (> 250) as shown in Table 2.6

Table 2.6: Size of Contractors

Type of organisation	Number of employees
Small	0 – 49
Medium	50 – 249
Large	> 250

Source: Lancaster *et al*. (2003); DTI (2005).

According to Lancaster *et al.* (2003) each of these organisations implements health and safety measures in a different way as summarised in Table 2.7.

2.6.7.1 Small Organisation

The majority of the small organisations have a health and safety officer or other manager in place, which had responsibility for managing the health and safety in close consultation with Managing Director (MD). In some cases, the health and safety of small contractors tended to be managed by the owner of the business. The majority of small contractors developed their health and safety systems in-house, although a small proportion bring in assistance from health and safety consultants

2.6.7.2 Medium Organisation

The majority of the medium contractors managed their health and safety via a structure whereby a local manager with various different role titles (e.g. Health and Safety Manager, Quality Manager, Production manager) had responsibility for day-to-day management of health and safety. The designated health and safety person would then report directly to the director or manager or the MD.

2.6.7.3 Large Organisation

The large contractors mainly managed their health and safety via a local health and safety manager who drove health and safety on a day–to–day basis with the health and safety system being approved, reviewed and over seen by Board at senior management level. Large contractors tend also to have the majority of health and safety expertise in–house, meaning that they were less likely to need or to seek external assistance from external health and safety consultants.

Table 2.7: Implementation of Health and Safety Measures by Organisation

Category	Small contractor	Medium contractor	Large contractor
Personnel	H & S officer. In many cases managed by the owner/MD	A local manager (e.g. H & S Mgr, Quality Mgr, Production Mgr)	A local H & S manager
System	Adhoc system overseen by owner/MD	H & S system overseen by senior management. H & S person would then report directly to another director or manager	H & S system approved, reviewed by Board at senior management level
Structure	Structure revolves around MD	Manage H & S via a structure responsible for day-to-day management of H & S	Manage H & S via a structure. Over seen by Board at senior management level
System Development	Develop H & S systems in-house Some external assistance in a few cases	External assistance in about 53% of cases	H & S expertise in–house Less likely to need or to seek external assistance

Source: Developed from Lancaster *et al*. (2003)

2.6.8 Other Drivers of Health and Safety

Contractors and designers have both opportunities to reduce risks. The removal, reduction and control of risks to health and safety begin within the design stage of a project (Levitt and Samelson, 1987). The designer must ensure that health and safety issues are considered in the design work and must provide adequate information on how to reduce risks to the contractor (Ferret and Hughes, 2005). Alternatively, early involvement of contractors at design stage improves their understanding of the health and safety risks inherent in the design and consequently, they can strategise to minimise or eliminate risks.

From all the foregoing discussions, it is clear that legal obligations currently constitute the biggest drivers of health and safety within construction companies. However, Ferret and Hughes (2007) argued that accident prevention in the UK construction industry is not just a matter of setting up a list of rules and making safety inspections, although both of these have their place. Holt (2001) suggested that what is required is a system for managing health and safety, which meets the needs of the business and complies with the law. Apart from complying with the law, there is a business case to be made for implementing health and safety strategies.

2.7 THE COST OF ACCIDENT PREVENTION

Levitt and Samelson (1987) argued that safety can only be achieved at the expense of cost. The costs of accident prevention are represented by the money expended by contractors to prevent accidents and are not normally included in the project cost and would, therefore, be additional expenses for contractors (Hinze, 1990). It is vital to identify these costs of accident prevention. The costs that are associated with accident prevention include provision of first aid facilities; PPE; safety training; safety promotion; safety personnel (Everrett *et al*. 1996; Tang *et al*. 2004; Oxenburg and Marlow, 2005)**.** These costs of accident prevention are both direct and indirect (e.g. opportunity cost) and may lead to both direct and indirect benefits.

2.7.1 First aid facility

The Health and Safety (First-Aid) Regulations 1981 require employers to provide adequate and appropriate equipment, facilities and personnel to enable first aid to be given to employees if they are injured or become ill at work. These Regulations apply to all workplaces including those with five or fewer employees and to the self-employed (HSE 2003). Although, first aid facilities may be the least common health and safety provision undertaken to prevent construction accidents. However, it can be argued that it plays a significant role by helping to prevent a minor injury from becoming a major injury. For example minor accidents and illness could be managed efficiently through early intervention, treating illness or accidents promptly and preventing acute accidents reducing major or even fatal accidents which could have otherwise meant a trip to hospital (Boot *et al.* 2005)

2.7.2 Personal Protective Equipment (PPE)

The PPE Regulations 1992 require the employer to provide without charge, 'all equipment (including clothing affording protection against the weather) which is intended to be worn or held by a person at work and which protects him against one or more risks to his health or safety', e.g. safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses (Strank, 1996). The provision of PPE can be argued to be the most significant element in terms of costs of accident prevention and prevention of accidents on construction sites. Therefore adequate provision of these equipments can help contribute to prevention of accidents on construction sites.

2.7.3 Safety Promotion

The Safety Signs Regulation 1980 under the Health and Safety at Work Act (HSWA) 1974 required that safety signs should conform to a standard system with regard to colours and shapes (Strank, 1996). Safety promotion aims to mobilise employees, suppliers and visitors to "think safe, act safe, feel safe and be safe" and then "Take the Steps to Safety" (HSE, 2003). It can be argued that safety promotions such as printing of pamphlets, banners can contribute effectively to accident prevention. It raises awareness and is important aspect of accidents prevention.

2.7.4 Safety Training

Training Regulation 28 under HSWA 1974 provides for a much wider provision of training for persons carrying out construction work (Ferret and Hughes, 2005 & 2007). All personnel must have sufficient training, technical knowledge or experience to ensure the reduction of risk of injury to others (HSE, 2003). According to Haslam, *et al*. (2005) training provides more directive instruction as to how an act should be performed. It is therefore suggested that training will enable them to recognise, analysis and establish accident prevention and control measures. Thus training is crucial to the prevention of accidents on construction sites.

2.7.5 Safety Personnel Salary

The health and safety personnel are important in implementing health and safety policy as they monitor safety related matters in the construction industry (Tang *et al*. 2004). The salaries of these personnel officers are also part of costs of accident prevention contractors should comply with to prevent accidents on sites. The salary for health and safety personnel is the largest investment for contractors possibly due to the requirement under the CDM 1994 Regulations.

The dilemma, on the surface, is that safety efforts will cost a given amount of money regardless of the occurrence of an accident, while the costs of accidents are incurred only if there is an injury. The economic question then is, should money be spent on health and safety measures when there might be no injuries even without the expenditures on safety? Tang *et al.* (2004) provides an answer to this question to the effect that if efforts are expended on safety, the probability of sustaining the high costs associated with accident becomes relatively small. However, if safety is not emphasized, the chance of sustaining a high cost of accident is markedly increased and the probability of sustaining no injuries is small. These probabilities are helpful to conceptualize the relationship between a commitment to safety and the occurrence of accidents. Hinze (1990) also provided an insight into this economic question by stating that if safety is emphasized, the occurrence of accidents can be expected to be low and, conversely, if no emphasis is placed on safety the occurrence of accidents can be expected to be high. If this fundamental premise is accepted, then, safety (and the costs associated with ensuring safety) is the most crucial investment contractors can make to prevent accidents on construction sites.

According to Morris & Willcock (1996) some constructions companies believe these costs associated with accident prevention are expenses and not an investment. From the argument above, it is clear that expenditure on accident prevention is an investment rather than an unnecessary cost to contractors. Booth *et al.* (2005) reinforce this argument that preventing accident is cost beneficial by stating that resources spent on preventing accidents can be justified exclusively on economic grounds. In addition, HSE (2007) suggested that accident prevention can bring real business benefits to contractors. According to Ferret and Hughes (2007) the question is not what it costs but what it saves. Therefore, there is a need to demonstrate that there is a business benefit, and this is what will help make the business case for prevention of accidents in the UK construction industry.

2.8 BENEFITS OF ACCIDENT PREVENTION

Benefit is defined as any gain to individual (Brent, 2005). Benefits can be gained by contractors in terms of reduced fatalities, major injuries and ill health through prevention of accident occurrences in the construction industry (Brent, 2003; Williams, 2005). These benefits can also be translated into monetary terms. According to Shearn (2003); Lancaster *et al.* (2003); HSE (2005); Ferret and Hughes (2007), these benefits can be perceived to offer both direct and indirect implications for the construction company's bottom line as shown in Table 2.8. It is suggested that when contractors are aware of these benefits of accident prevention, it may encourage them to spend more on health and safety issues.

Table 2.8 Direct and Indirect Benefits of Accident Prevention

Direct benefits	Indirect benefits
Saving in Insurance Premium;	Productivity Improvement
Saving on Medical Expenses	Saving on Sick Pay;
Saving on Compensation Claim	Saving on Working day lost
Saving on Damage Materials	Saving in lost time
Saving on Litigation	Saving on Cleaning/ Waste Disposal
Saving on Accidents Investigation	Saving on hiring of Tools and Plants
Saving on safety training	Saving on image improvement
Savings in loss of life	Staff morale
	Job satisfaction

Source: Shearn (2003); Lancaster *et al.* (2003); HSE (2006); Ferret and Hughes (2007)

It is also suggested that these benefits stemming from prevention of accidents are likely to accrue to contractors if they spend more on accident prevention. The construction industry is definitely a business and accidents affect the bottom line (Howarth and Watson, 2009). Levitt and Samelson (1987) demonstrated clearly that safety management pays off handsomely in financial as well as humanitarian terms. However, contractors need to be convinced of these business benefits in their decision making to invest more on health and safety measures. It may therefore, be argued that to demonstrate these benefits, it would be useful to undertake a cost benefit analysis (CBA) of accident prevention within the context of current approaches for delivering construction projects.

2.9 INVESTIGATING THE RELATIONSHIP BETWEEN COSTS AND BENEFITS

Whilst it has been clearly established that there are benefits accruing from investment in health and safety, what remains unclear in the literature is the magnitude of such benefits. Although it has also been suggested by Tracey (2005) that benefits accruing from preventing accident occurrence are likely to be greater than the cost of an accident in the construction industry it is also unclear the magnitude by which such benefits outweigh the costs. This reinforces the need to undertake a CBA of accident prevention. The main challenge of undertaking a CBA to evaluate the relationship between costs and benefits is that of expressing both the costs and benefits in monetary terms so that the comparison can be made. This is discussed in chapter 4. It is suggested that when both the costs and benefits are quantified, the comparison of the two can be done to establish a cost and benefit relationship.

2.10 SUMMARY

This chapter has presented a review of the literature focusing on the causes and costs of accidents in the UK construction industry, measures to prevent accidents, the costs of accident prevention, as well as the benefits of accident prevention. Critically, the review also focuses on health and safety legislation and other drivers of health and safety, and discusses how they affect accident prevention and costs. As can be seen from the health and safety performance in the UK construction industry (refer to chapter 1), it is clear that preventing accidents is very important in the construction industry. To consider this theme from the perspective of the business case, the case has been made in this chapter for comparative analysis of the costs and benefits deriving from accident prevention through the application of cost benefit analysis (CBA). The next chapter, (i.e. chapter 3) reviews the principles of CBA and make a case for its applicability to the construction health and safety context.

CHAPTER 3

A CRITICAL REVIEW OF THE COST BENEFIT ANALYSIS (CBA) APPROACH

3.1 INTRODUCTION

This chapter reviews the principles of CBA and makes a case for its applicability to the construction health and safety context; thus, addressing the second key objective of this research. The chapter traces how the use of CBA has developed and its theoretical underpinnings, and then investigates how it has been applied in various other contexts. It then explores how this technique may be adapted for application in the construction health and safety context. The chapter argues that the application of CBA to health and safety in the construction context, potentially, offers an opportunity to understand the relationships between the costs and benefits of accident prevention in construction industry. This chapter, therefore, will have important implications for the development of a cost benefit conceptual framework to investigate accident prevention costs and benefits.

3.2 BACKGROUND TO CBA

Harberger and Jenkins (2002) defined CBA as a set of tools for guiding decisions on whether or not to take a particular course of action. Pearce (1988); Snell (1997); Preez (2004) defined CBA as a methodology for valuing costs and benefits that enables broad comparisons to be made and prescribes classes of benefits and costs to consider, means to measure them, and approaches for aggregating them. Carcoba (2004) described CBA as a technique designed to determine the feasibility of a project by quantifying its costs and benefits, which can be used to evaluate the social costs and benefits of an investment project. Watkins (2006) further described CBA as the process of weighing the total expected costs versus the total expected benefits of one or more actions in order to choose the best or most profitable. Barker and Button (1995) described CBA as a practical way of assessing the desirability of projects where it is important to take a long view and a wide view. According to Kopp *et al*. (1997), CBA is generally used in comparing projects whether a project contributes a net economic benefit to the public welfare and is meant to convey some normative information to decision-makers, namely, whether a policy could make the society better off than the status quo. CBA is typically used either for a yes/no decision on whether a single course of action will be undertaken or not, or to choose between two or more competing courses of action (Harberger and Jenkins, 2002). Thus, CBA provides a means of comparing both cost and benefits and also helps policy and decision makers to better understand the role it can play in helping them fulfil their decision making responsibilities (Lagas, 1999). With the knowledge of CBA background, it is considered important to trace the origins of the CBA.

3.3 ORIGINS OF CBA

The original theoretical basis for CBA, as a technique of economic evaluation for public investment was laid in the 1930s when the US corps of engineers devised a methodology to justify dam projects to the congress (Lagas, 1999). The first systematic use of CBA was in US investment decision concerning the North American water resources programmes of the 1930s (Pearce, 1988; Bjornstad, 2006). It was observed that massive public expenditure was being undertaken to develop selected river valleys and the public benefits from such schemes was perceived to be uncertain. Since the 1930s, CBA has been a popular tool for evaluating public sector projects and is one of the oldest techniques that were developed in the USA to assess the implications of alternative water resources schemes and its application rapidly expanded to a variety of public sector activities in all parts of the world (Preez, 2004). Carley (1987) gave example of such public activities as transportation planning and resources development area. Thus, the earlier uses of CBA were concerned to bring quantitative appraisal into the process of the allocation of public resources in an attempt to realise greater economic efficiency. In late 1960s and early 1970s, the CBA framework was also further developed as a technique for project evaluation that could be used across economies (Harberger and Jenkins, 2002).

The development of CBA in the late 1960s was extended to developed and less developed countries with the publication of a manual industrial project analysis (kiltle & Mirrless, 1969 as cited in Pearce, 1988). The UK government in 1967 gave formal recognition to the existence of CBA and assigned a limited role for nationalised industries. While in 1972, the United Nations industrial development organisation (UNIDO) published its own guidelines different in detail but essentially with the same philosophy (Mishan, 1982). This implies that the CBA has been in use in several countries with its application in different context. In the context of health and safety, applying CBA is like any other techniques where there are scarce resources to be allocated and therefore decisions have to be guided (cf. Harberger and Jenkins, 2002). Therefore, this technique can be applied to compare cost and benefits of accident prevention to guide contractors' decision making.

3.3.1 Decision – making Criteria:

There are three criteria used in decision making. These are Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR) (Preez, 2004). One or more of three can be used for decision making (Preez, 2004).

Preez, (2004) defined NPV as the discounted sum of all net benefits i.e. the different between the cost and benefit over the economic life of the project and more formerly:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

Where:

NPV = net present value

B_t = benefit after t years

C_t = cost after t years

N = number of years

$(1 + r)^t$ = factor which the difference between B_t and C_t is discounted.

The discount rate is t.

The NPV must be positive where a choice has to be made and the one with the highest NPV will be chosen (Harberger and Jenkins, 2002). However, the NPV measure profits only and has its own problem such as the selected discount rate. The costs and benefits of accident prevention are both direct and indirect therefore; the NPV will only take care of the direct and not the indirect costs and benefits. This means that whatever results come out of it will be incomplete. It should be noted that the research focuses on cost and benefit (direct and indirect) of accident prevention, therefore, the NPV can not be used to calculate the costs and benefits of accident prevention

In the internal rate of return (IRR) method, the criterion for acceptance of a project is that the IRR must exceed the social discount rate. Given two independent projects and a budget constraint, the one with the higher IRR should be accepted before the one with the lower rate (Preez, 2004). The IRR is that rate of discount which makes the present value of the entire stream – benefits and costs – exactly equal to zero (Mishan, 1982) more formerly:

$$IRR = \sum_{t=0}^{n} \frac{B}{(1+r)^{t}} \text{ t = 0}$$

The IRR is another method for determining value that does not depend on the determination of a discount rate and that expresses value in terms of a percentage. The IRR is based on the assumption that the cost benefit flows are reinvested at the internal rate of return (Glaister & Layard, 1994). Therefore, the IRR can not be used to calculate the costs and benefits because the IRR may yield results that are inconsistent with a ranking based on the NPV method. The method requires the compounding of all positive cost benefit flows to the last period of the project life period, at a given rate.

The BCR is defined as the ratio of the present value of the benefits relative to the present value of the costs (Preez, 2004) more formally:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} \quad = \text{B/C}$$

BCR = Benefit cost ratio.

The criterion for acceptance a project is that the discounted BCR must exceed one. For choices among mutually exclusive projects the acceptance rule would be to select the project with the highest discounted BCR. However, the typical problem with discount rate is getting the cash flow correct.

Another method is the willingness to pay (WTP). The WTP for improved health is a function of the productivity improvement (Morris and Willcocks, 1996) and is expressed as:

WTP = PP + CS

Where PP = price paid

CS = consumer surplus.

The WTP reflects the amount that someone who does not have a product would be willing to pay for it. It represents the maximum amount of money that individuals would be willing to pay in exchange for an improvement in circumstances or consumer surplus brought about by a policy (Pearce, 1988; Glaister & Layard, 1994). In order to tackle the causes of days lost through accidents and to improve production in the construction industry, the willingness to pay approach could be used to acquire the benefits or to avoid costs (cf. Mishan, 1982).

The choice facing the decision maker is which of these many methods to apply in CBA of accident preventions on construction projects. If the discounted NPV method is adopted, the question for the appropriate rate of discount arises. In such exceptional cases there would then seem to be no more justification for discounting such future benefits to be enjoyed by contractors in the construction industry. Though, NPV represents an effective method to be adopted as it is both consistent and acceptable. However, CBA focuses only on either the mean or mode of the NPV or IRR this on its own as argued by (Barker and Button, 1995) does not provide enough information for a valid decision where projects may be uncertain. The WTP method also has the potential to contribute to a reduction in costs and may be appropriate to compute the benefit of accident prevention on the basis of individual willingness to pay. This implies that when applied to accident prevention policy, it will seek to obtain the amount that contractors are willing to pay to improve health and safety in the industry. However, this method will not give the actual cost of accident prevention as it is limited to the amount contractors are willing to pay. The BCR is the simpler form which contractors can assess benefits of accident prevention in proportion to their investment on health and safety measures (cf. Preez, 2004). Therefore, the BCR will be adopted in the calculations of the costs and benefits of accident prevention to guide contractors in their decision making process. Mishan (1982) pointed out that CBA must derive the parameters of analysis wholly from rational economic criteria and without regard for any politically determined values. This means that the calculations of benefits and costs exercise should be made on a purely economic principle.

3.4 APPLICATION OF CBA IN THE UK

The first serious attempts were made to apply CBA in the UK in early 1960s (Mishan, 1982). The attempt was in the economic assessment of the first stage of the M one motorway between London and Birmingham (Pearce, 1988; Snell, 1997). This exercise was carried out after the motorway had already been constructed; set up the basic methodology for CBA appraisal of major transport undertakings. After the M one motorway study of 1960, there followed an important appraisal of the construction of the Victoria underground railway in 1963-5 and the comprehensive investigation into the 3rd London airport between 1969 and 1970 marked the coming of age of CBA in the

UK. This was followed by large scale applications, which include investment decisions on motor, underground railways, airports, reservoirs and flood relief schemes as well as power stations and most recently, the channel tunnel scheme. While the smaller scale uses of CBA include the evaluation of local authority housing investments and the local provision of car parks and recreation facilities (Snell, 1997). Thus, CBA has been widely used in the UK to assist government decision making on social investment. Apart from the UK, CBA has also been widely used in Asia and USA and has even gained recognition at government level to simplify decision making (Bjornstad, 2006). Its effective use led to preserve environment or health in the USA through the Environmental Protection Agency and also has been introduced in other context such as agricultural projects, health context, water supply and electricity or gas, education and transport (Snell, 1997; Harberger and Jenkins, 2002).

Significantly, the subject of CBA has consistently worked itself up the occupational safety and health agenda in the last few decades (OSHA, 1989). For example, a Swedish forestry contractor experienced high levels of work-related injuries over a decade and, in 2004, carried out a CBA on investments to try and decrease these injury levels (Johanson & Johren, 2006). This was introduced to decrease work-related injuries and to achieve a higher rate of productivity. The successful outcome led to CBA now playing an important part in the contractor's decision-making processes at work. And in Japan, the business environment surrounding Japanese industries was very strict for few years because of long stagnation forcing executives to adopt effective management to make the most of limited resources (Japan Industrial Safety and Health Association, 2000). This prompted the Japanese Government to introduce CBA especially in developing new safety measures. The implementation led to improvement of production and productivity rate, improvement of work motivation, and improvement of corporate image in Japan. With evident from various applications of CBA as stated above, it is argued that CBA can be applied to prevent accident on construction sites and improve construction health and safety performance. However, in order to apply CBA to construction health and safety, the contractors have to do an economic CBA to find out whether it is desirable or acceptable from the economic view point. This may help to prove the viability of carrying out a CBA to help estimate the benefits accruing from its application.

CBA needs to be distinguished from cost-effectiveness analysis (CEA). CBA seeks to bring greater objectivity into decision making and is considered as an economic evaluation, which compares the costs and benefits, where they are converted to monetary values. The CEA seeks to maximise the extent of achievement of a given beneficial goal within a predetermined budget or, alternatively, to maximize the expenditure required to achieve a pre-specific goal (Booth *et a*l. 2005) as further explained in Table 3.1

Table 3.1 Difference between CBA and CEA

CBA	CEA
CBA is a systematic, quantitative method of assessing the costs and benefits of competing alternative approaches	CEA is a simplified CBA, which can be done when either the benefits or the costs are the same for all the alternatives
Considers only one programme at a time	CEA is comparative
compares monetary costs and benefits of a programme	CEA often compare programmes on the basis of some other common scale for measuring outcomes.
	Assume a certain benefit is desired and there are several alternative ways to achieve it

Source: Developed from Weimer and Vining (1992).

The basic questions asked in CBA are: Do the economic benefits outweigh the costs and is it worth doing at all? (Weimer and Vining, 1998). In a CBA, there are advantages and disadvantages (Weimer and Vining, 1998).

Advantages of CBA

- Helps set priorities when resources are limited;
- Can be extremely powerful and persuasive to policy makers - may convince them to invest in particular kinds of programmes.

Disadvantages

- There are no standard ways to assign monetary values to some qualitative goals especially in social programmes such as time, human lives saved or quality of live;
- Market costs don't always reflect real social costs e.g. one person's cost is another person's benefit.

The main tasks doing a CBA are to identify the right costs and benefits to be considered in the analysis and to estimate the various prices to be assigned to them (Snell, 1997). Harvey (1987) suggested that this can be done by identifying all the relevant benefits and costs of a particular scheme and quantifying them in monetary terms so that each can be aggregated and then compared. Therefore, the first step in CBA is to identify all relevant costs and benefits ((Briscoe, 1993; Snell, 1997).

3.4.1 Identification of Relevant Cost and Benefit Elements

The key issue in CBA is the identification and measurement of all relevant costs and benefits associated with the proposed project (Briscoe, 1993). Brent (2003) defined cost as anything that imparts a loss and benefit as any gain to individual. Lindqvist and Lindholmn (2001) described costs as the values of the real resources used. There are different types of costs that exist such as economic, social, opportunity and sunk costs.

1. Economic cost

Economic cost is concerned with maximum benefits within available resources (Pindyck, 1992). The economic cost of accidents in the construction industry includes the costs associated with both direct and indirect, for example, insurance, litigation, investigation, medical treatment as well as production costs. These accidents costs are associated with the resulting economy loss to the contractor, worker, society and the UK economy (HSE, 2004).

2. Social cost

The social cost accounts for the losses attributable to death, pain and suffering incurred by worker, emotional and psychological impacts caused to family members and friends of the affected worker (HSE, 2004). The examples of social costs are death, pain, suffering as results of accidents occurrence. These social costs are not quantified in this research but are merely stated as examples of costs to contractors, workers and society (refer to chapter 1 section 1.2).

3. Opportunity cost:

Snell (1997); Harberger and Jenikins (2002) defined opportunity cost as what is given up to get something. Mishan, (1982) described opportunity cost analysis as an important concept in company's financial decision-making processes. Glautier & Underdown (2001) noted that economist favours opportunity cost as appropriate costs for decision-making. (Pindyck (1992) had argued that opportunity cost is useful when evaluating the cost and benefit of choices. Harberger and Jenikins (2002) reinforce this argument that the principle of opportunity cost can be applied to both costs and benefits. Therefore, it can be argued that the opportunity cost is a relevant cost concept which can be applied to health and safety when the problem facing the contractor may be a problem of choice. Example of opportunity costs are: cost of labour; sick pay and costs for machinery running idle (HSE, 2004; Oxenburg and Marlow, 2005).

4. Sunk cost:

Pindyck (1992) defined sunk cost as an expenditure that has already been made and cannot be recovered. Layard & Glaister (1996) described sunk costs as the cost incurred in the past and savings or efficiency already achieved should not be considered in a CBA. They are costs already incurred before the moment of the decision, which CBA is to guide; therefore, they cannot be affected by their decision (Pearce, 1988). The CBA weighs the benefits and costs, therefore, the sunk; costs have nothing to do with it (Harberger and Jenikins, 2002). This therefore, implies that the sunk costs have nothing to do with application of CBA on accident prevention. It is a cost that can not influence contractor's decisions, because doing so would not be rationally assessing a decision exclusively on its own merits. Having identified some different types of costs, it is important to discus how this costs and benefits are measured.

3. 4. 2 Measuring Costs and Benefits

As noted in section 3. 2, costs and benefits can be measured and weighed up against each other in order to generate criteria for decision making. However, in measuring costs and benefits, two concepts of cost are important in CBA and these are financial costs and resources costs, sometimes called budget and economic costs (Carley, 1987). Financial costs are the monetary values of actual goods and services such as costs of material, manpower, facilities, information and other overhead costs, which often have market values and are easily expressed in monetary terms (Novozhilov, 1997). Resources costs on the other hand involve opportunity forgone and refer to the benefit which might have been gained had the resources been employed in their next best alternative use (Carley, 1987). This suggests that cost and benefit can be expressed in some sort of common unit of measurement to decide if the benefit is greater than the cost (cf. Harberger and Jenikins, 2002). It requires the benefit to be put in the same unit with the cost. When the benefits and costs are in the same unit, they can be measured and weighed up against each other in order to generate criteria for decision making. For example, in measuring costs and benefits, Jacobs (1980) identified two different analyses related to costs and benefits in health care. The first is the measures of the total economic costs that are created by disease and allow a comparison of the impact of different classes on diseases. The second analysis involves measure of the costs of disease. Therefore, it is necessary to assign some monetary value to the costs and benefits so that the CBA can be conducted in monetary value. One of the techniques use is called contingent valuation.

3.4 .2.1 Contingent Valuation

Haab and McConnel (2003) describe contingent valuation as a process by which analysts, typically, pose contingent or hypothetical questions to policy affected individuals asking them to state their willingness to pay for a specified public policy. The idea is to stimulate marketed goods and obtain a value for that good, contingent on the hypothetical market described during the survey (Wedgwood and Sansom, 2003 as cited in Hammond, 2006). Thus, in applying to health and safety, the survey will seek to obtain the amount contractors directly spend on prevention of accidents on construction site and value of the benefits of such accident prevention for the purpose of estimating the economic value of cost and benefit. The limitation of contingent valuation is that it depends on what people say rather than on what they do, and the consequences can only be partially mitigated by good methodology (Snell, 1997). However, this method has been applied in the area of estimating economic benefit of preserving or enhancing environmental quality and the determination of the willingness to pay for portable water and sewerage services (Snell, 1997).

3.4.3 Research Application of CBA

In order to reduce and eventually eliminate construction accidents, researchers have explored techniques implemented by different construction parties to realise 'zero-injury objective' (Hinze and Huang, 2006). However, considerably fewer efforts have focussed on the application of CBA to construction health and safety. The use of CBA to calculate maximum benefits can be of fundamental importance to construction accident prevention. The calculations of CBA, typically, involve computing costs and benefits in order to choose the best or more profitable action (Pearce, 1988). Thus, it can be especially useful for contractors to guide their decision making on health and safety issues. Some of the research applications are thus, discussed below.

3.4.3.1 Health and Safety Related Studies Using CBA

Several researchers have proved that there is a strong positive relationship between health and safety and improved safety performance. This includes Nicholson *et al.* (2006) which investigated cost-benefit studies that support tackling musculoskeletal disorders (MSDs) and established an important tool in persuading UK business to adopt good practice in tackling MSDs by demonstrating that ergonomics interventions at workplace can prevent MSDs and benefit business financially. According to Nicholson *et al. (*2006), in the UK business competing in a market- driven global economy, business owners, shareholders, managers and their advisers need to be persuaded that business investments is sound that it will provide a good return on investment and, increasingly, that it will form an integral part of their goal to meet good practice in social responsibility. Nicholson *et al.*'s research aimed to encourage organisations to consider savings that they would make by preventing musculoskeletal disorders rather than looking at the costs when making decisions about expenditure on measures to reduce musculoskeletal disorders. The research covers the entire UK industry without any particular reference to construction industry and moreover it looked at how musculoskeletal disorders can be prevented. The research finding is generalised, therefore, the insights can not be used to assist contractors in their decision makings on costs and benefits of accident prevention in the UK construction industry.

Boyd *et al.* (2006) investigated the true cost of occupational asthma in Great Britain to raise awareness among employers, workers, and policy makers as to the potential gains to be realised from adopting measures to reduce the incidence of occupational accident. It found that the average worker suffering from occupational accident is estimated to lose between 3.5 and just over 4.5 work days per year. The costs to society were estimated to range from £71.7m to £100.1m. The research investigated what occupational asthma would cost the society but failed to estimate what benefits the society will derive from preventing occupational asthma. Moreover, there is limitation in the research, the occupational asthma cost was generalised without specific reference to the UK construction industry. On the bases of this, it can be argued that this research can not encourage contractors to spend more on accident prevention.

Peebles *et al.* (2003) conducted an investigation into Analysis of Compensation Claims related to health and safety issues to collect and analyse health and safety (accident and injury – related) compensation claims via trade unions and law firms and found that the main types of claims received were as a result of accidents from slips, trips and falls (16%), manual handling (10%) and exposure to noise (7.6%) and also stress accounting for 16% and this occurred mostly on construction sites. It can be acknowledged that the research however, has some relevance to construction accidents that lead to costs of accident to contractor. In spite of this, the research fails to investigate if health and safety measures were in place to prevent these accidents that lead to compensation claims. As noted in chapter 2, compensation claims result from accident occurrence. Therefore, it can not assist contractors in their decision making to spend more on accident prevention without calculating what the benefits of accident prevention are.

HSE (2005) developed on-line interactive tools for contractors to assess the cost of accidents to their organisations. These costs, as identified by HSE, are: lost time; sick pay; damage or loss of product and raw materials; repairs to plant and equipment; extra wages, overtime working and temporary labour; production delays; investigation time; fines; loss of contracts; legal costs; and loss of business reputation; sickness absence; overtime payments; lost production; missed deadlines; cost of recruiting and retraining of staff. Although the developed tool provides useful guidance to contractors on what accidents can cost them, however, it is not sufficiently detailed to specifically assist contractors in developing effective and efficient health and safety management systems. For instance, the tool refers to cost estimates of accidents but does not take into account what are the actual costs and the benefits of accident prevention. The on-line developed tool focussed solely on what accidents could cost organisations. It can further be argued that the extent to which the tool has been utilised in the construction industry to realise the intended aims and objectives are still vague. Take for instance the fatal accident occurrence in 2006/07 that rose sharply from 59 in 2005/06 to 77 (23.4%) (refer to chapter 1 section 1.2 page 4). Thus, this HSE initiative is not adequate to guide contractor's decision making on costs and benefits of accident prevention. Relying on such a cost calculation without calculating the benefits obviously can not guide contractors in their decisions making.

Lancaster *et al.* (2003) conducted a study for HSE to assess whether the costs of compliance with HSE regulations are disappropriate across different sizes of organisation, what the nature of expenditure is and how effective the activities have been in improving health and safety performance. The study adopted quantitative methodology to undertake the survey. The research identified that costs of compliance were disappropriate across different sizes of organisation. The study focussed on the management of health and safety at work regulations across all industries. The finding from the study indicates that large contractors with greater than 250 employees report considerably less expenditure for accidents compared with small and medium organisation of less than 250 employees. The study identified main motivators underlying the development of health and safety systems as legal obligation (particularly large contractors) and the main frustrations were time restriction, costs, lack of information and skill. This study refers to the entire industries and is not particular to construction industry. It can be, therefore, argued that there is relatively less information available on costs and benefits of accident prevention in the UK construction industry that can convince contractors in their decision making from this study.

3.4.3.2 Construction Related Studies Using CBA

Everett *et al*. (1996) examined the total cost of accidents in the USA and employed the use of a quantitative method and defined costs to consist of direct costs (e.g. insurance premium, legal fee) and indirect costs (e.g. transportation of injured worker to the hospital, wages paid for time not work, overtime costs, cost of replacement worker, cost of repair/clean up or replace damage from the accidents, cost of investigation). The results showed that the total costs of accidents rose from 7.9% to 15.0% of the total cost of project. Even though this study provides the total costs of accidents, however, it failed to consider the costs and benefits of accident prevention which would have encouraged contractors to spend more to prevent accidents. Thus, it is not possible to tell if these costs are excessive or worth the benefits of accident prevention.

Tang *et al.* (2004) examined the costs of safety incurred by building contractors on sites in Hong Kong using a mathematical model by dividing the total equivalent day loss by the total man-hour. Tang *et al.* (2004) employed quantitative methods and defined costs of site accidents to include loss due to the injured person, loss due to medical expenses, and loss of time of other employees to attend to accident victim, equipment or plant loss, loss due to damaged material or finished work. The costs also include investment in the salary of personnel employed to monitor safety and investment in the purchasing of equipment such as safety boots, goggles, helmets, first aid facilities and other equipment that has to do with the provision of safety measures on site, and the cost of training and promotion. Promotion includes the printing of pamphlets and posters, the production of safety advertising boards and banners, and the organisation of safety campaigns.

Tang *et al.* (2004) provided a method for safety cost optimization. The theory relies on two assumptions.

1. That there is a positive relationship between investment in safety and safety performance- i.e. the higher the safety investment, the better the safety performance;
2. That there is a negative relationship between accident costs and safety performance – i.e. if safety performance is good, accident costs will be low.

Tang *et al.* (2004) presented these relationships as curvilinear and labelled the two relationship curves as ‘safety investment ratio (SIR) and accident costs ratio (ACR). The ratio aspect was introduced so that both costs could be compared in percentage. The underlying assumption, that an investment in personnel is associated with improved performance is central to Tang *et al*. theory. Thus, there were limitations in Tang *et al.*’s calculations. For instance, Tang *et al.*’ s study provides the costs of accidents prevention in relation to the financial losses of contractors; however, it fails to consider the financial benefits of accident prevention. Thus, it is not possible to tell if the cost outweighs the benefit On the bases of this, it can, therefore, be argued that Tang *et al.'* s calculation may not convince contractors in decision making to invest more on safety measures. However, Tang *et al*.'s acknowledge that intangible benefits could be realized through increased investment in safety. Based on Tang *et al*. (2004) findings, the authors suggested that a safety investment greater than 0.6% would result in intangible benefits, such as greater peace of mind of workers, better reputation of the company, greater job satisfaction, which they admitted were not considered in the mathematical model but are valuable assets to contractors. The results showed that the optimal safety investment was found to be approximately 0.6% of the contract sum and the total costs to contractor (accident loss + safety investment) was found to be 0.82% of the contract sum.

Oxenburg and Marlow (2005) examined the direct costs of injury and hidden costs (cost of overtime, training, supervision, labour turnover, waste and rework, loss production, reduced productivity) in the construction industry. They employed qualitative and quantitative approaches (mixed method) and used a CBA model to assess the total costs of employment and the losses due to injury in the workplace. The results showed that by using analytical tools, the effectiveness of an intervention might be estimated prior to its introduction. Although this study provides the costs of accidents, however, it fails to consider the costs of accident prevention that would have led to these costs of accident as well as the benefits of accidents prevention. It can further be argued it is not possible to tell if these costs are excessive or worth the benefits of accident prevention. Therefore, contractors can not use the study to assist them in their decision makings on costs and benefits of accident prevention.

Booth *et al.* (2005) examined the economic impacts of construction safety in Greece to determine the overall costs of safety, namely the sum of the costs of accidents, the costs of effective preventive efforts and the costs of management failures not involving an accident. The results show that the overall costs of safety for a principal contractor were very small compare with the overall project budget, but up to 11.5% of gross profit. The study described the development of the challenges associated with an accident and accident prevention costing technology. However, the study demonstrated that the 'business case' for the pursuit of zero accidents in the construction industry is economically justified. The study of the costs of accidents and their prevention revealed that the total safety costs represented between 2.2% and 11.5% of the project gross profits. Though, this study demonstrated the costs of accident and accident prevention. However, it fails to consider the benefits that can be derived from expenditure on costs of accident prevention. It can be argued that this alone may not convince contractors to spend more on costs of accident prevention to generate benefits of accident prevention. Thus, it is important to compare costs and benefits of accident prevention in order to convince contractors to choose the best alternatives i.e. decision to spend more on costs of accident prevention or not as business is about making profit.

All these models are generally more concerned with theoretical description than with practical investigation of costs and benefits of accident prevention. There are limitations in these models developed by various researchers. These models do not deal with the extent to which costs of accidents prevention and benefits of accident prevention can be compared to choose the best option. No attempts have been made to investigate the costs and benefits of accident prevention to contractors, which may reduce the cost of accidents. Previous studies merely attempted to investigate causes and costs of accidents, why never investigated how much benefits could be derived from accident prevention. Furthermore, there is still a lack of explanatory detail in these models about which cost of accident prevention factors influenced benefit of accident prevention and makes a significant contribution to health and safety performance on construction sites.

It can be argued further that even though these studies critiqued highlight useful applications of CBA, there is limited evidence that it has been applied for analysing accident prevention. It is against this background that a CBA approach is conceived as a means of complementing current efforts. It is suggested that CBA can help determine if the benefits of accidents prevention exceed the costs of accident prevention. This suggests that CBA can be used by contractors to guide them in their decision making if the benefit of accident prevention is worth the cost of accident prevention. For example, decisions like whether or not to spend more on costs of accident prevention. Although, previous costing studies may have added valuable insight into different costs of accident, however, there is little work in the current literature about the construction industry where attempts to model the contribution of CBA of accident prevention have been demonstrated. This highlights the gap in knowledge that must be addressed. CBA was adopted here to show that benefits of accident prevention can be achieved for better safety performance in the construction industry.

3.5 APPLICATION OF CBA TO ACCIDENT PREVENTION

Drawing from other studies where concept of CBA has been applied successfully to such areas as real estate policy impact (Hammond, 2006), noise at work regulation 1989 (Honey *et al.* 1996), musculoskeletal disorder (Nicholson *et al.* 2006), construction of tornado shelters (Whalen *et al.* 2004), it is suggested that CBA offers the potential to improve construction health and safety management. CBA, potentiality, is not yet recognised and properly tapped for effective health and safety performance in the construction industry. A review of previous health and safety research studies confirmed the need for effective accident prevention on construction sites. Shut (1995) suggested that the improvement of construction health and safety management will reduce accident costs and contribute significantly to the well being of the workers, employers and society. To contribute significantly to the well being of the workers and reduction of accidents, Carpenter (2006) suggested the need for effective health and safety management that must be addressed to deliver safe and good projects. Therefore, it is suggested that application of CBA approach might lead to significant cost savings of accident prevention and improvements in construction safety performance. While acknowledged various researches on health and safety studies that had been completed in the past, there had no been serious attempt to address the accident prevention in the context of costs of accidents prevention and benefits of accident prevention. The use of CBA can improve production in the construction industry and also benefits workers, employer and society.

The introduction of the CBA could guide professional decision makers in early stages of project development and provide them with access to relevant safety and health concerns so that preventive action or design modification could be made to reduce or eliminate accidents. Such health and safety performance has the potential to benefit owners, designers, estimators, managers and of course workers. Designers can use the system to build safety into the project's design. Estimators will be guided in identifying appropriate health and safety requirements so that responsible bids are prepared to account for health and safety project costs. It can, therefore, be concluded that CBA of accident prevention can be developed to raise contractors' awareness of the importance of cost and benefit in relation to health and safety performance in the construction industry. Evidence suggests that there have been few investigations as to the CBA of implementing a rigorous health and safety management in the UK construction industry. It can be seen that the evidence from the preceding section shows that CBA can be applied to accident prevention in a construction context. However, this requires identification and quantification of costs and benefits for effective prevention of accidents.

3.6 QUANTIFICATION OF CBA

One important tool of quantifying CBA is the benefit to cost ratio which is the total benefit divided by the total cost (Weimer & Vining, 1992, Preez, 2004) as discussed in section 3.3 In order to quantify economic benefits and costs of accidents, they must be expressed in monetary terms. Since CBA provides a mean of weighing the cost of prevention to reduce accidents against the benefit that would result, it is necessary to assign monetary values. Where all benefits and costs can be expressed in monetary values, CBA provides decision makers with a clear indication of the most efficient alternative, that is, the alternative that generates the largest net benefits to society (Georgi, 1993). CBA focuses on the future. Therefore, decisions have to be based on the costs and benefits of proposed alternatives (Seeley, 1996). CBA should be explicit about the underlying assumptions used to arrive at estimates of future benefits and costs. The underlying assumption that an investment in accident prevention is associated with improved performance is central to the research. This includes comprehensive estimates of the financial benefits and costs of accident prevention. In the course of quantifying the benefits of reducing the costs of fatality, pains and suffering, problems may arise putting value on human life. Financial aspects such as insurance payouts, compensation payments and court fines will no way be enough to compensate for loss of human life. It can be stated that these principles need to be consolidated into a framework which would provide a systematic base for CBA of accident prevention in construction.

3.7 SUMMARY

The chapter traces how the use of CBA has developed and its theoretical underpinnings, and then investigates how it has been applied in various other contexts. It then explored how this technique may be adapted for application in the construction health and safety context. The justification for applying this technique in the UK construction industry context is re-emphasised. The potential of using CBA for improving the management of construction health and safety in the construction industry was also discussed. Decision makers can identify potential improvements on health and safety management through the use of CBA. The introduction of CBA can help contribute to accidents prevention on construction sites and help to achieve a higher rate of productivity. It is capable of being used effectively for improving health and safety management in the construction industry. The implementation of health and safety management using CBA in the UK construction industry should lead to benefits such as improvement of production and productivity, improvement of corporate image of the organisation. The next chapter, (i.e. chapter 4) is the development of a CBA conceptual framework of accident prevention that captures the benefits of accident prevention and contrasts these with the costs of accident prevention, to show the potential for achieving an overall net benefit.

CHAPTER 4

CBA OF ACCIDENT PREVENTION: A CONCEPTUAL FRAMEWORK

4.1 INTRODUCTION

This chapter focuses on the development of a conceptual framework based on the literature review of health and safety and CBA. From the review, it was identified that health and safety measures may lead to costs which have economic impact on contractors and also may lead to benefits which accrue from accident prevention. In order to investigate these costs and benefits of accident prevention, it is necessary to have a conceptual framework that brings together these key parameters to be investigated to aid the data collection phase of the study. In chapter 3, it was argued that CBA could offer decision support tools for health and safety management in the construction industry thereby widening accident prevention efforts. This chapter consolidates that argument by putting forward a framework that theoretically establishes the costs and benefits of accident prevention, and integrates these elements to highlight the potential economic case for accident prevention.

4.2 TOWARDS A THEORETICAL FRAMEWORK

From the literature review, it was evident that the on-line tools developed by HSE in 2005 and other sources of information on costs of accidents in the construction industry were inadequate for decision making on construction health and safety measures. The tools currently available lack the ability to utilize construction information relating to health and safety, which could enable the identification of benefits to contractors of improved health and safety performance (see chapter 3). Without the identification of benefits, alongside the costs of accident prevention, consideration of the economic case for accident prevention becomes impossible. Thus, it was reasoned that the application of a CBA approach could provide both the insight and understanding of cost and benefits of accident prevention required by duty holders to stimulate a safety performance improvement agenda.

It was asserted that the challenges in health and safety demand understanding of the CBA of accident prevention. It was emphasised in chapter 3 that an effective CBA may be used to demonstrate that there is a good justification for investing in health and safety. Fundamentally, the concept requires the weighing of the benefits of prevention against the costs of accident prevention measures that have been implemented (Boot *et al.* 2005). This implies a need for identification and quantification of all the components of accident prevention as well as identification and quantification of all the benefits accruing from such preventative measures. Building on from chapter 2, where the relevant components of accident prevention and the benefits were identified, it is possible to integrate these elements into a framework that theoretically reflects the dependency of any potential benefits on the measures of accident prevention actually implemented, as shown in Figure 4.1. It is from this framework that the parameters relevant for this research can be considered and extracted. The framework in Figure 4.1 highlights the interdependencies that exist between the costs of accidents and the costs of accident prevention (which according to Fellows *et al.* (2002) together constitute the cost of health and safety), as well as the benefits of accident prevention.

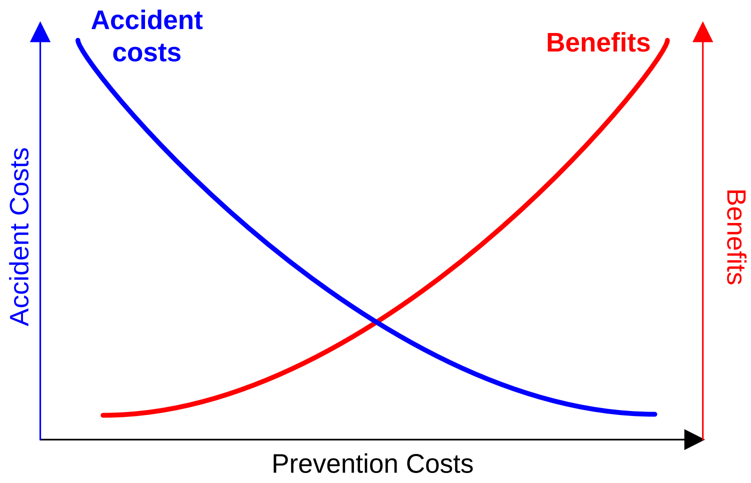

Figure 4.1: The relationships between health and safety costs and benefits

Adapted from: Fellows *et al.* (2002) and Tang *et al*. (2004)

Figure 4.1 suggests an inverse relationship between accident costs and prevention costs, as well as between accident costs and benefits, whilst there is a positive relationship between prevention costs and benefits. A detailed discussion and explanation of each of these components of accident prevention, and the relationships highlighted by Figure 4.1 now follows.

4.3 COSTS OF HEALTH AND SAFETY

The costs incurred by contractors on account of health and safety are divided into two categories both of which contribute to the overall financial losses of contractors (Fellows *et al*. 2002). The first is the 'costs of accident prevention (health and safety measures)'. According to HSE (2004), Tang *et al*. (2004), Ferret and Hughes (2007), they are expenses invested directly by contractors to prevent accidents. The second is costs of accident (direct and indirect) which arise from the occurrence of accidents despite the fact that safety measures were in place. Accidents contribute to the costs of construction, directly through increased compensation and insurance and indirectly through decreased productivity, quality non-conformances and schedule overruns (Ferret and Hughes, 2007). The cost of accidents is easily understood by contractors and represents a tangible measure which can be related to project financial accounts and both the income statement and balance sheet of a contractor (Tang *et al.* 2004; Booth *et al.* 2005). Thus, this category of cost is very often at the fore of considerations of the costs of health and safety. However, when undertaking a CBA of accident prevention, the relevant costs to consider are the costs associated with the preventative measures implemented by contractors to eliminate accidents or minimise their impacts. For the purposes of this research therefore, the emphasis is placed on accident prevention costs.

4.4 COSTS OF ACCIDENT PREVENTION (SAFETY MEASURES)

The costs of accident prevention are primarily incurred by contractors to improve health and safety management and outcomes in the construction industry. As previously mentioned in chapter 2 and highlighted in Fig 4.2, it refers to costs related to the following (see Everett *et al.* 1996; Tang *et al.* 2004; Oxenburg and Marlow, 2005; HSE, 2006):

- first aid;
- PPE;
- safety training;
- safety promotion;

- safety personnel.

From chapter 2, it can be seen that there are legal requirement for the provision of a safe working environment. It is also a fact that where legal requirements impose added cost, this lends itself to a situation where duty holders only strive to achieve minimum requirements or worse still flout the law where there is chance that they can escape detection (cf. Fellows *et al*. 2002; Ferret and Hughes, 2007). Given that construction organisations are businesses that exist to make profit and grow, it is reasonable to propose that added to these legal imperatives must be an economic incentive to ensure safety. In an era when controlling costs and time in projects is a significant factor, it will not be possible to ignore the economic arguments (Haslam, 2002) where it can be demonstrated that managing health and safety has an impact on cost and time outcomes. This notion finds support from Fellows *et al.* (2002) who argue that construction companies will adopt accident prevention activities more readily, if managers are convinced that they are worthwhile financially. With the consensus that a reduction of the costs related to accidents is desirable (for instance HSE recommends that construction industry totally eliminate accident in the workplace (HSE, 2005), it makes it all the more critical that this argument is put to the test.

As shown in Figure 4.1 and argued cogently in Fellows *et al.* (2002), costs expended on accident prevention lead to a reduction in risk and consequently a reduction in accidents. A reduction in accidents can influence construction performance and overall profitability by reducing the costs associated with accident occurrence. A logical progression of this argument is that the greater the investment in health and safety measures, the greater the reduction in accident costs. A simplified representation of this inverse relationship is shown in Figure 4.2 which illustrates the argument that as less is expended on accident prevention and mitigation through first aid, PPE, safety training, safety promotion and safety personnel, during project delivery this translates into greater accident costs, both direct and indirect as explained in Chapter 2.

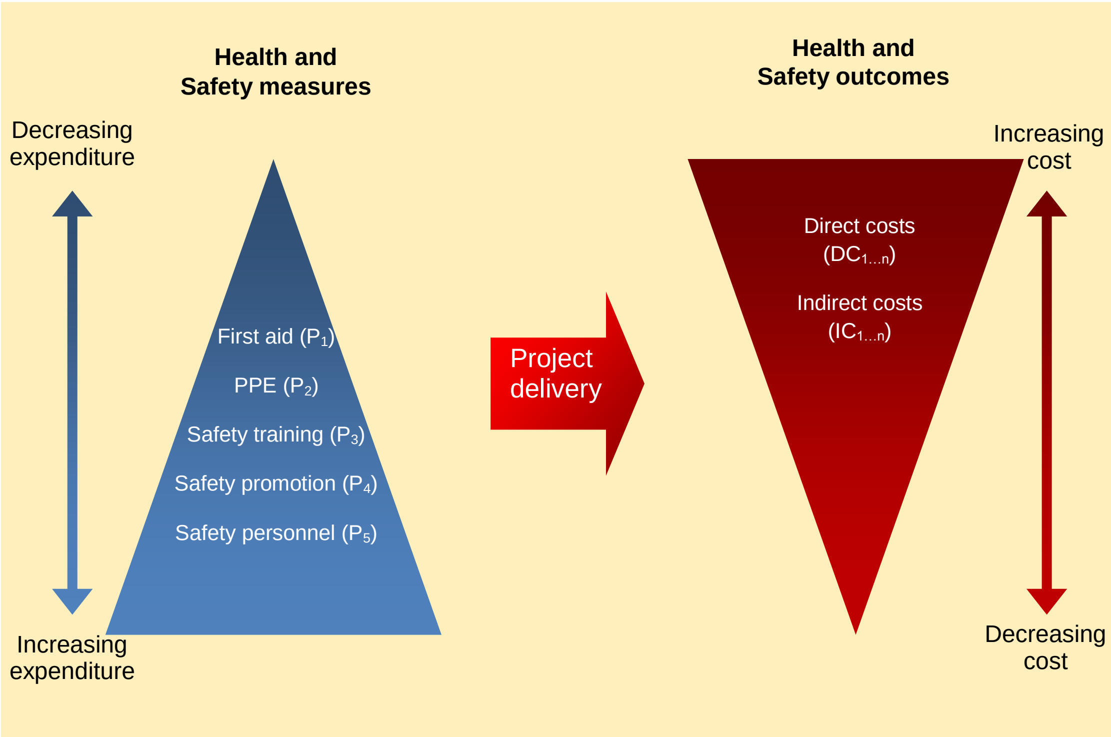

Figure 4.2: The relationship between cost of prevention and cost of accidents

The proposition therefore, is that to secure greater reduction in the costs of accidents, there must be greater expenditure on health and safety measures. Table 4.1 lists the direct and indirect costs of accidents and the health and safety measures where costs must be expended to secure the reduction in costs. A significant challenge for contractors is to reduce accidents by taking effective action or measures to reduce the risks of accidents and ill health (Lanoie & Tavenas, 1996)

Table 4.1 Costs of Accidents and their Associated Prevention Costs

Cost caused by accident	Prevention costs
Worker illness	P_1, P_2, P_3, P_4, P_5
Cost related to damaged machinery/equipment	P_3, P_4, P_5
Accident insurance premium	P_1, P_2, P_3, P_4, P_5
Litigation cost	P_1, P_2, P_3, P_4, P_5
Loss due to damage or break of machinery	P_3, P_4, P_5
Losses related to working days	P_1, P_2, P_3, P_4, P_5
Losses incurred by contractors	P_1, P_2, P_3, P_4, P_5
Bad reputation	P_1, P_2, P_3, P_4, P_5
Waste disposal	P_1, P_2, P_3, P_4, P_5
Death	P_1, P_2, P_3, P_4, P_5
Permanent disability	P_1, P_2, P_3, P_4, P_5
Pains and discomfort	P_1, P_2, P_3, P_4, P_5
Increased absence	P_1, P_2, P_3, P_4, P_5
Damage to property/building	P_3, P_4, P_5
Fines and cost from prosecution	P_1, P_2, P_3, P_4, P_5
Cost of investigation	P_1, P_2, P_3, P_4, P_5
Cost of temporary labour	P_1, P_2, P_3, P_4, P_5
Cost related to recruitment and replacing competent worker	P_1, P_2, P_3, P_4, P_5
Cost of overtime payment	P_1, P_2, P_3, P_4, P_5
Cost of extra material	P_3, P_4, P_5

Where: P_1 = First aid
P_2 = PPE
P_3 = Safety training
P_4 = Safety promotion
P_5 = Safety personnel

Adapted from: HSE (2006)

The challenge then is to be able to quantify the expenditure on prevention and the corresponding accident costs that are associated with such expenditure, so that the inverse relationship can be quantitatively tested and the most effective actions can be determined. This is a gap that HSE (2006), from which this table was derived, has not addressed.

4.5 BENEFITS OF ACCIDENT PREVENTION

The benefits of accident prevention derive primarily from the savings that contractors make by not incurring the costs associated with accidents (Tang *et al*. 2004; HSE, 2005; Ferret and Hughes, 2007). Consequently, it can be proposed that as costs associated with accidents decrease, contractors save more and therefore, there is a corresponding increase in the benefits derived by contractors. This inverse relationship is captured in Figure 4.3 which shows that similar to costs, benefits are direct and indirect as stated by Shearn (2003), HSE (2006) and Ferret and Hughes (2007) and discussed in chapter 2.

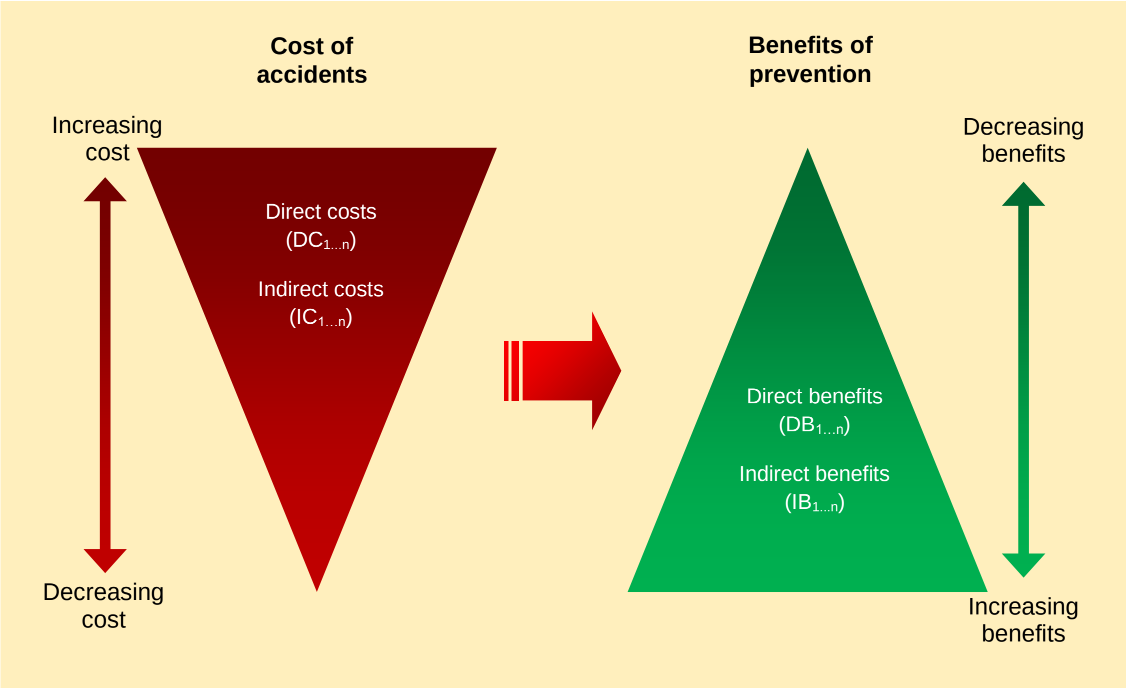

Figure 4.3: The relationship between cost of accidents and benefits of prevention

The costs of accidents, both direct and indirect as discussed in chapter 2 are summarised in Table 4.2 with a brief outline of the health and safety measures that mitigate those costs and the benefits that are derived from saving such costs as suggested by HSE (2005). Whilst the quantum of costs and savings are not clear from Figure 4.3 and Table 4.2, anecdotal evidence shows that investing in accident prevention can help reduce costs and consequently, provide benefits that are hard to ignore (Holt, 2001; Lancaster *et al.* 2003). In addition, HSE (2005) demonstrated that reducing the costs of accident would avoid waste of both human and material resources. Moreover, the HSE (2004) pointed out that human life, health and the well being of future generations are priceless.

Table 4.2 Costs of Accidents and their Associated Benefits

Cost caused by accident	Associated benefits
Worker illness	Avoiding loss in human life, pains, and suffering of the affected workers, emotional and psychological impacts cause to friends, families and colleagues, less staff turnover, less absenteeism
Cost related to damaged machinery/equipment	Capital savings on repairs, installation Improving product/ productivity rate
Accident insurance premium	Avoiding insurance premium, civil compensation
Litigation cost	Avoiding litigation cost, sanction and penalty
Loss due to damage or break of machinery	Avoiding loss of capital savings on repairs, installation, improving product/ productivity rate
Losses related to working days	Avoidance of lost work time or absenteeism
Losses incurred by contractors	Avoiding loss of product/productivity rate, quality of work
Bad reputation	Avoiding loss of chances of winning more contract and corporate image
Waste disposal	Avoiding loss of extra material
Death	Avoiding loss of human life, pains, and suffering of the affected workers, emotional and psychological impacts cause to friends, families and colleagues, loss to employer and society
Permanent disability	Avoiding pains, and suffering of the affected workers, emotional and psychological impacts cause to friends, families
Pains and discomfort	Avoiding loss of Job satisfaction, morale, improving staff efficiency
Increased absence	Avoiding lost work time or absenteeism
Damage to property/building	Avoiding capital cost and construction cost, productivity and profitability
Fines and cost from prosecution	Avoiding litigation cost and civil compensation
Cost of investigation	Savings on litigation, insurance premium, accident cost
Cost of temporary labour	Opportunity cost, increase in productivity rate/product and profitability
Cost related to recruitment and replacing competent worker	Increase in production and productivity rate Less staff turnover
Cost of overtime payment	Capital savings on financial losses
Cost of extra material	Capital saving on financial loses

Source: HSE (2005)

4.6 COMPARING COSTS AND BENEFITS OF ACCIDENT PREVENTION

By extracting the relevant elements from the foregoing arguments and models, it is possible to evolve a conceptual framework that reflects the hypothesised relationship between expenditure on health and safety measures and benefits of accident prevention, and identifies all the key parameters that primary data must be collected on (Figure 4.4). In particular the framework emphasises the positive association between accident prevention expenditure and the quantum of benefits. It also acknowledges that the benefits may be both direct and indirect, a fact which is crucial in ensuring that the process of quantifying the benefits captures all relevant benefits no matter how remote. This conceptual framework (Figure 4.4) thus provides a robust platform for data collection for the purpose of CBA.

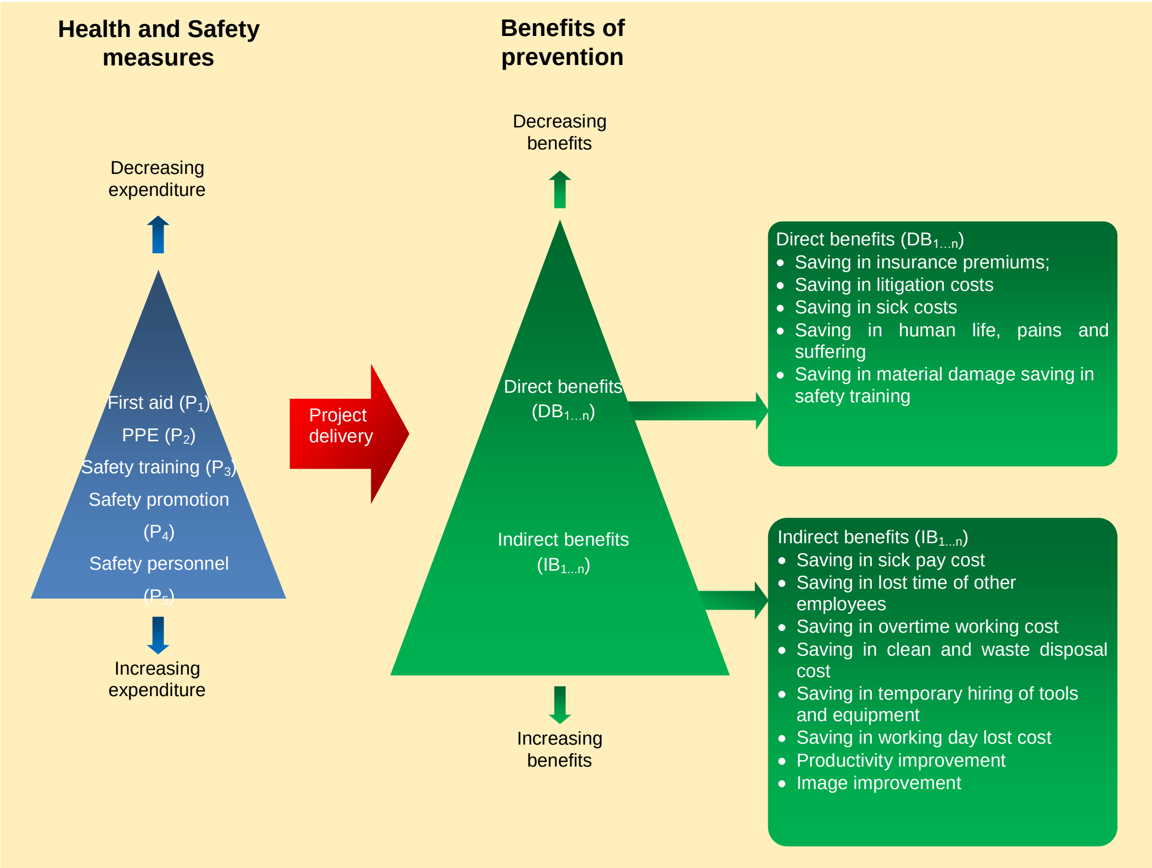

Figure 4.4: The components of accident prevention and associated benefits

Source: Tang *et al.* (2004); HSE (2005); Ferret and Hughes (2007)

A number of hypotheses can be posited on the basis of this conceptual framework as follows:

H_0: That large contractor spend a greater percentage of their turnover on health and safety measures than small and medium contractors

H_a: That small and medium contractors spend a greater percentage of their turnover on health and safety than large contractors

H_o: That large contractor enjoys greater benefits from accident prevention than small and medium contractors

H_a: That small and medium contractors enjoy greater benefits from accident prevention than large contractors

H_o: That indirect benefits are greater than the direct benefits associated with accident prevention

H_a: That direct benefits are greater than the indirect benefits associated with accident prevention

H_0: That benefits of accident prevention outweigh the costs of accident prevention

H_a: That costs of accident prevention outweigh the benefits of accident prevention

H*o*: That there is a positive relationship between costs of accident prevention and benefits of accident prevention -i.e. the higher the cost of accident prevention, the higher the benefit of prevention;

H_a: That there is a negative relationship between costs of accident prevention and benefits of accident prevention -i.e. the higher the benefit of accident prevention, the lower the costs accident prevention.

These hypotheses will be tested as part of the CBA process.

In order to carry out a CBA, it is necessary to express both the costs and benefits in monetary terms as explained in chapter 3 section 3.6. A direct comparison can then be made once both costs and benefits are expressed in such monetary terms (Lindqvist and Lindholm, 2001). Thus, it is possible to directly compare the costs and benefits. In order to compare costs and benefits, it is first necessary to establish a valid and reliable means of measuring them.

4.7 MEASURING COSTS AND BENEFITS OF ACCIDENT PREVENTION

Measuring economic benefits of accident prevention is usually much more difficult than measuring their economic costs. Some benefits such as avoiding loss of human life, pains, and suffering of the affected workers, emotional and psychological impacts cause to friends, families and colleagues, loss to employer and society, job satisfaction, staff morale are difficult to express in monetary terms. As argued previously in chapter 3 section 3.4.2, however, benefits could be measured in terms of monetary savings in accident costs. In order to measure monetary benefits of accident prevention, data regarding the costs of accidents prevention and savings from accident prevention must be obtained from contractors. The accident criteria that will be used is the one defined by the HSE (1998) as 'any unplanned event that resulted in injury to people, damage or loss to property, products, material or the environment or a loss of business opportunity (see chapter 2).

Furthermore, CBA focuses on the future, and is based on the expected costs and benefits of proposed alternatives (Seeley, 1996). In this regards, it is suggested that information collected will be about future effects of decisions, preferably expressed in monetary terms, to facilitate the CBA process. Where all benefits and costs can be expressed in monetary units, CBA is an excellent tool for providing decision makers with a clear indication of the most efficient alternative that generates the largest net benefits to society (Georgi, 1993). Detailed consideration of each of the following issues is undertaken next:

- Assignment of monetary values to preventative measures and benefits;
- Quantification of cost of prevention and benefit of prevention.

4.7.1 Assignment of Monetary Values

Of the various costs and benefits of prevention considered, the preventative measures can be more readily assigned a monetary value. However, for reduced cost of accidents such as fatality (death), it may also be difficult to assign a monetary value. Assigning monetary values gives a rhetorical question. Can a meaningful cost applied to accidents? For material losses in which no injury occurs, the accounting of losses can be easily assessed. Where human loss is concerned, the costing becomes difficult and burdened with ethical pitfalls. A life or a human facility can not be credibly evaluated in terms of money (Fellows *et al.* 2002).

Frank *et al.* (2002) suggested a number of approaches to assigning a value of a statistical life in terms of the economic output which is (1) cost when a person is killed (2) Willingness To Pay (WTP) approaches – estimate the amount that people in society would be prepared to pay to avoid a statistical fatality (3) court awards – damages to dependant for wrongful dead reflect only their share of income the victim would have earned (i.e. net output approach). The issue of calculating or quantifying statistical life can not be rigorously addressed within the CBA calculations and are better dealt with qualitatively by the decision makers (refer chapter 3 section 3.3).

4.7.2 Quantifying the Costs of Accident Prevention

Cost of preventative measures can be calculated using estimates provided by contractors. It can be abstracted from records of the costs of safety in terms of the provision of PPE, first aid facility, safety promotion, safety training and safety personnel (cf. Tang *et al.* 2004). These preventative measures are mostly materials which contractors purchased and provisions made and should have record of purchase. Sinclair (1972) as cited in Frank *et al.* (2002) quantifies accident costs by breaking accidents down into three parts: fatalities, serious (major) injuries and other (minor) injuries, the cost of accidents was expressed as:

$$C_A = R_D + (A_{OD}) + R_S\,(A_{SS} + A_{OS}) + R_O\,(A_{SO} + A_O)$$

Where C_A = annual accident cost per worker

R_D = annual risk death per worker

R_s = annual risk of serious injury per worker

R_O = annual risk of other injury per worker

And average A_S = subjective element of cost

A_O = objective element of cost

While D, S and O for death, serious injury and other injury.

The use of simple summation of annualised costs by Sinclair (1972) could be employed using prevention cost (in place of cost of accidents) and cost of accident prevention can be represented as:

$$CP = P_1 + P_2 + P_3 + P_4 + P_5$$

Where CP = Annual cost of prevention

P_1 = Annual cost of first aid facility

P_2 = Annual cost of PPE

P_3 = Annual cost of safety promotion

P_4 = Annual cost of safety training

P_5 = Annual cost of safety personnel

By adding together the prevention costs, the total expenditure on safety prevention can be achieved in order to determine benefit / cost ratio. Then, the value of the costs of prevention can be compared against the benefits of accident prevention.

4.7.3 Quantifying the Benefits of Accident Prevention

The benefits of accident prevention can be quantified in terms of the reduced costs of accidents such as savings in material damaged, insurance premium, investigation, productivity losses, image improvement, medical costs, lost time, hiring of tools, working day lost, sick pay and safety training. As mentioned previously in section 4.6.1, some of these items such as job satisfaction and staff morale may be difficult to quantify, but a rough minimum estimate can be made using proxies like court fines and insurance as benchmarks as well as subjective assessments (Fellows *et al*. 2002; Tang *et al*. 2004).

As with the costs of prevention, benefit can also be represented as:

$$BP = IP + PI + CC + MC + CI + MD + WL + SP + LC + AI + ST + LT + TH$$

Where BP = benefits of prevention (savings)

IP = insurance premium

PI = productivity improvement

CC = compensation claims

MC = medical care

CI = company image

MD = material damage

WL = working day lost

SP = sick pay

LC = litigation cost

ST = safety training

LT = lost time of other employees

TH = tools hiring

According to Frank *et al.* (2002), this approach can be criticised for the time lag between the institution of prevention measures and their effect, which this approach does not take into account. That notwithstanding, it can still be used as a yard stick by which accident prevention programmes can be evaluated (Frank *et al.* 2002).

4.7.4 Implications for Data Collection

The developed conceptual framework reveals relationships between health and safety measures and benefits of accident prevention. This conceptual framework will need to be tested. This will require the collection of data on cost of accident prevention and benefits of prevention from construction organisations to test the hypotheses and reveal the nature and significance of the costs and benefits. This data will need to be collected through an appropriately designed research methodology.

4.8 SUMMARY

The discussion addresses the development of a CBA conceptual framework of accident prevention. The conceptual framework developed brings together, in a logical manner, all the essential aspects of costs and benefits to be investigated, and provides appropriate parameters and points of reference for the investigation. The CBA framework thus, provides a platform for this research to identify costs and benefits of accident prevention and measure the difference between these benefits and costs. Insight derived from such analysis is critical to providing managers and decision makers with an opportunity to evaluate the outcomes of strategies relating to accident prevention, thus enabling them to make decisions in a more structured or systematic manner. The next chapter, (i.e. chapter 5) presents a detailed outline of the research methodology adopted for undertaking this research.

CHAPTER 5

RESEARCH METHODOLOGY

5.1 INTRODUCTION

This chapter describes and justifies the research methodology that was adopted to develop a CBA model of accident prevention on construction projects. There are three principal research approaches that can be employed in the social sciences, namely qualitative, quantitative and mixed methods (Creswell, 2003). To understand the basis upon which the research methodology was adopted, these methods are first discussed. Arguments are presented justifying the choice of the approach and the specific research methods applied in data collection. The methodology employed is considered to be the most appropriate strategy in the context of this study for collecting data on cost and benefit of accidents prevention. The data collection procedure is also described. Subsequently, the relevant information on the potential respondents, the sampling frame, and the sample size are presented.

5.2 RESEARCH APPROACH

There are three approaches to research (Creswell, 2003): Qualitative, quantitative and mixed methods. These three approaches will now be discussed in detail commencing with the qualitative approach.

5.2.1. Qualitative Approach

Smith (1983); Lincoln and Guba (1985) described the qualitative research approach as an enquiry process of comprehending a social or human problem /phenomenon based on building a complex holistic picture formed with words, reporting detailed views of informants and conducted in a natural setting. Walker (1997) and Creswell (2003) further described qualitative methodology as explanatory in nature with the principal aim of trying to unearth answers to how? and why? questions. In qualitative research, theory or hypothesis are not established a priority. The research questions may change and be refined as the enquirer learns what question to ask. The qualitative research is not suitable for this research because of the sensitive nature of the questionnaire and the types of information sought are highly confidential and is not concerned with issues of discovery. In addition, the conclusion drawn will not be generalised and not related to a particular event (Creswell, 2003). The method can be used to better understand and to gain new perspectives on issues about which is already known, or to gain more in-depth information that may be difficult to convey quantitatively. The draw back of qualitative research is that data collection methods are often labour intensive and it has also been criticized for being subjective to researcher bias. There also exist difficulties in analysing qualitative data rigorously and there is a lack of reproductively and generalisability of the findings (Richard, 1996). The qualitative approach is associated with strategies such as phenomenological, case studies, ethnographies, narratives and grounded theory (Creswell, 2003).

5.2.1.1 Strategies Associated with the Qualitative Approach:

The strategies associated with qualitative approach are summarised in Table 5.1. A number of authors (e.g. Seymour and Rooke (1995) and Rooke *et al*. (1997) have advocated for the use of these strategies in construction management research.

Table 5.1 Strategies Associated with Qualitative Approach

Enography	Grounded theory	Case study	Phenomenological	Narrative
The researcher studies an intact cultural group in a natural setting over prolong period of time by collecting, primarily observational data	The researcher attempts to derive a theory of a process, action behaviour or interaction grounded views of participants in the study; It focuses attention upon the way in which scientific work which is necessarily concerned with issues of discovery or generatively.	The researcher intends to support his or her argument by an in-depth analysis of a person, a group of persons, an organisation or a particular project. The nature of the case study focuses on one aspect of a problem, the conclusion drawn will not be generalised but, rather, related to one particular event.	The investigator identifies the "essence" of human experiences concerning a phenomenon as described by participants in a study. The researcher 'brackets' his or her experiences in order to understand those of the participants in the study	Form of enquiry in which the researcher studies the lives of individuals and asks one or more individuals to provide stories about their lives. Narrative analysis is subjective and it does not give adequate coverage in all lines of work.

Source: **Rooke (1995); Rooke *et al*. (1997); Creswell (2003)**

In qualitative research, there are various methods of collecting data (Hancock, 1998 as cited in Manase, 2008), which includes:

- Interviews;
- Focus groups;
- Direct observation;
- Case studies.

5.2.1.2 Interviews

Patton (1990) sets a list of types of interviews, which can be structured, semi structured or unstructured, with the approach used dependent on both the stage of the research and the nature of the data or information being sought. The various types are described as follows:

1) Structured interviews

Structured or standardised interviews are used predominantly in surveys and opinion polls with consequent quantitative analysis. In structure interview, every interviewee receives the same questions in the same specified order to achieve statistical comparability. The questions tend to require specific answers and are closed ended. There is no latitude or flexibility allowed to either the interviewer or the respondent.

2) Semi-structured interviews

Semi-structured interviews can be used either as part of a structured interview or an unstructured interview. An interview guide may be developed for some parts of the study without fixed ordering of questions so that some direction is given to the interview. This gives greater flexibility than the closed-ended type and permits a more valid response from the respondent's perception of reality.

3) Unstructured Interviews

An unstructured interview takes the form of a conversation between the respondent and the researcher. It focuses, in an unstructured way, on the informant's perception of themselves, or their environment and of their experiences. There is no standardised list of questions. It is a free flowing conversation, relying heavily on the quality of the social interaction between the researcher and the respondent that can be subtly redirected by the interviewer if it should stray too far off the track of the research study.

Thus, while it is made to be as natural as possible, the direction of the conversation is always controlled somewhat minimally to ensure the focus stays relevant to the problem.

5.2.1.3 Focus groups

Focus groups are a form of group interview that capitalises on communication between research participants in order to generate data (Burns, 2000). Although group interviews are often used simply as a quick and convenient way to collect data from several people simultaneously, focus groups explicitly use group interaction as part of the method. This means that instead of the researcher asking each person to respond to a question in turn, people are encouraged to talk to one another: asking questions, exchanging anecdotes and commenting on each others' experiences and points of view (Powell and Single, 1996 as cited in Manase).

5.2.1.4 Direct observation

Direct observation refers to observing and studying those participating in a research study. It is usually used when data collected through other means can be of limited value or is difficult to validate (Burns, 2000).

5.2.1.5 Case Studies

The case study approach is used to gain in-depth understanding of the subject, focusing on process rather than outcome, on discovery rather than confirmation (Burns 2000). Patton (1990) described case studies as particularly useful in depicting a holistic portrayal of a client's experiences and results regarding a program. For instance, to evaluate the effectiveness of a programme's processes, including its strengths and weaknesses, evaluators might develop cases studies on the programme's successes and failures. This implies that a case can be individuals, programmes, or any unit, depending on what the programme evaluators want to examine through in-depth analysis and comparison. Thus, a case study must involve the collection of very extensive data to produce understanding of the entity being studied. It is the preferred strategy when ‘how’, ‘who’,’ why’ or ‘what’ questions are being asked, or when the researcher has little control over events, or when the focus is on a contemporary phenomenon within a real life context. In a case study, the focus of attention is on the case in its idiosyncratic complexity, not on the whole population of cases (Burns 2000).

Following the numerous strengths of interviews as to their use in exploratory data collection (see for example, Hofstede *et al.* (1990), Creswell’s (2003), this method was adopted as the appropriate technique for collecting qualitative data required for this phase, which was aimed at exploring the costs and benefits associated with accident prevention. Interviews are also known as the most effective and widely used qualitative method in organisational research (King, 1994). The interview was specifically designed to capture what health and safety practitioners think of the developed conceptual CBA framework for accident prevention on construction projects.

5.2.1.6 Design of Interviews

The interviews were required to provide information on specific questions related to the development of CBA model for accident prevention on construction projects. This investigation was aimed at answering the how and why questions of the research, which could not be satisfactorily answered through postal survey; for example, how would you describe health and safety performance in your organisation? According to Yin (1994), such questions require the adoption of qualitative research inquiry approach involving the use of in-depth interviews', experiments and case study for collecting the required information. It became clear that experiments and case study were not favourable for this research given the confidential nature of the issues being investigated. This leaves interviews as the most favourable option to use. There are various methods for administering interviews (Creswell, 2003). The nature and scope of the issues to be investigated by the interviews suggested the structured open-question as the most appropriate option for designing the interview questionnaire. This format as suggested by Patton (1990); Bogdan and Bikklen (1992) allowed interviews to give responses they thought were right thereby minimizing bias that was often associated with closed ended interviews. It also makes it possible for pursuing and probing for relevant information to help clarify some of the responses in some instances (Patton, 1990; Creswell, 2003).

5.2.1.7 Interview Data collection

Following the design of the interview questionnaire, the interviewees were contacted on phone to arrange for appropriate interview date, time and place. For each interview, interviewees were first briefed on the purpose of the interview and its expected duration. They were also assured that information received would be kept strictly confidential and their written consent was obtained. In the course of the interviews, a number of steps were taking to ensure proper conduct and avoid any possible biases from creeping in, including (Patton, 1990) (i) asking one question at a time; (ii) remaining neutral as far as possible by trying not to show strong emotional reactions to responses, for instance; and (iii) taking control of the interview by sticking closely to questions of interest.

5.2.1.8 Interviews

The interviewees were identified from the database of contractors listed in the UK Kompass (2006) register. The interview was an opportunity to ignore prior ideas and to draw on the knowledge of practitioners without imposing biases or knowledge obtained directly from the literature or experience (c.f Nicoline, 2002). Like Hofstede *et al*. (1990), the intention was to paint a qualitative empathetic description of the cost and benefit of accident prevention. Interviews were conducted with 13 (thirteen) health and safety personnel who represented small (<50) medium (<250) and large (>250) contractors. The aim was to provide a standard framework through which the costs and benefits of accident prevention could be explored in further detail. Their involvement in health and safety issues made them highly suitable for the interview. The participants were approached directly to participate in the research. Participants had an average of 12 (twelve) years working experience. Generally, each interview took between 30mins - 1hour to complete, where information was recorded by note talking. Average duration of these interviews was 30 minutes. The results of the interviews are analysed in chapter 6. However, this qualitative phase of the research was thus, explanatory in nature and was intended to help in validating the conceptual framework, which was found difficult to explore quantitatively.

5.2.2 Quantitative Research Approach

Creswell (2003) defined quantitative research as the one in which the investigator primarily uses both positivist and post positivist claims for developing knowledge on the truth about quantitative measures and employs strategies of inquiry such as experiments and surveys and collects data on predetermined instruments that yield statistical data. Naoum (1998); Creswell (2003); Anderson (2004); Punch (2005) described the quantitative research as an enquiry into social or human problem based on testing a theory composed of variables, measured with numbers and analysed using statistical procedures in order to determine whether the predictive generalisation of the theory hold true. Naoum (1998) provides an example of quantitative methods as particularly important in businesses' where managers often talk about improving productivity, increasing return on investment, scheduling production, and forecasting demand, increasing customer service. There are strategies of inquiry associated with the quantitative research approach.

5.2.2.1 The Quantitative Strategy of Inquiry

In conducting quantitative research, three main approaches are typically employed. These approaches are identified by Fellows and Liu (1997) and Creswell (2003) as 'desk, experiments and survey', as explained in Table 5.2. Fellows and Liu (1997) described desk research as suitable for studies in such areas as macro-economics where data can not be obtained by any other viable alternatives and is also problematic. It involves using data by others, perhaps analysing it in alternative ways to yield fresh insight. Hammond *et al.* (2000) described experiment as a test of cause-effect relationships by collecting evidence to demonstrate the effect of one variable on another. The experiments include the random assignment of subjects to treatment conditions as well as quasi-experiments that use non-randomised designs (Keppel, 1991). Surveys on the other hand involve cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection, with the intent of generalising from a sample to a population (Babbie, 1990). The survey approach was adopted for this study because of the various advantages it has over others and because of its strength in enabling attributes of a larger population to be identified from a small group of individuals (Babbie, 1990).

Table 5.2: Quantitative Strategy of Inquiry

Desk	Experiment	Surveys
Though cheap, time saving and suitable for studies but problematic. Data collected may not be tailored for the research being undertaken Sampling may not be wholly appropriate to the requirements of the research. The data may have inherent limitations due to the manner in which it was collected.	Test the impact of a treatment or an intervention on an outcome, whilst controlling all other factors (the determinants or cause-independent variables) that might influence the outcome; Achievable in laboratory conditions and sometimes with human subjects; Carried out with the greatest amount of control in (near) laboratory condition	The data on relevant variables is collected at the same or within a relatively short time frame In cross-sectional survey, all the data on relevant variables is collected at the same or within a relatively short time frame; In longitudinal surveys, data is collected over a long period of time

Source: Fellows and Liu (1997); Black (1999); Babbie (2000); Creswell (2003)

5.2.3. Mixed Methods Approach

A mixed method approach is one in which the researcher tends to base knowledge claims on pragmatic grounds (e.g. consequence, oriented, problem-centred and pluralistic) (Creswell, 2003). This method employs strategies of inquiry that involve collecting 2 (two) main sets of data either simultaneously or sequentially depending on the nature of the research problems. The data collection also involves gathering both numeric information (e.g. on instruments as well as text information (e.g. interviews) in these stages so that the final database represents both qualitative and quantitative information. In mixed methods, the researcher bases the inquiry on the assumption that collecting diverse types of data best provides an understanding of a research problem. Having discussed qualitative and quantitative and mixed method approach, the next section discusses the criteria used for selecting the methodology for the research.

5.2.4 Criteria for Selecting a Research Methodology

The driving forces for the choice of a research methodology in any study are not the advantages or disadvantages associated with a particular method (Creswell, 2003). The factor that influences the choice of approach over another is the nature of the research problem or the objectives of the study (Creswell, 2003; Mertens, 2003). Therefore, certain types of research problems call for specific research methodologies and the nature of the research problem under investigation by the researcher largely determines the specific methodology to be adopted. Where for example, the nature of the problem is such that the objective of the study is to test or explain an existing theory, then the quantitative method is the best approach. However, if a concept or phenomenon needs to be understood because little research has been done on it then it merits a qualitative approach to be adopted (Creswell, 2003).

5.2.5 Research Methodology Adopted for the Study

The study has been driven from the onset by the quest to derive largely quantitative measures of costs and benefits of accident prevention in the UK construction industry. This commitment, dictates the choice of a largely quantitative approach and research method as the foremost paradigm for this study. The quantitative research (positivist) method is all about quantifying relationships between variables (Egbu, 2007). According to Mark (1996) and Punch (2005), quantitative research methods assume that there is a single objective reality. As such, two independent researchers can use standard research methods to study a particular problem, and both will arrive at the same conclusion (Egbu, 2007). This is different from a qualitative approach, which sees research as exploratory and evolving as the project develops and, thus, capable of influencing and being influenced by outcomes (Creswell, 2003). Qualitative inquiry relies on text and image data, while mixed method procedures employ data collection associated with quantitative and qualitative approaches (Creswell, 2003). While there are many alternatives to choose from, selecting a potentially useful option requires careful thought and planning (Fellows and Lui, 1997). In good research, the choice should be appropriate, reasonable and explicit (Ahadzie, 2007). Failure to ignore these fundamentals can lead to very poor research.

A major factor that influenced the choice of the quantitative survey strategy was the large and diverse nature of the research population (contractors) across the UK. According to Rea and Parker (1997), there is no better method of research than a quantitative survey for collecting information about a large population. Surveys are also viewed as the most appropriate method of studying participants' behaviour and job perception (Mintzberg, 1993; Rea and Parker, 1997). As noted in Walker (1997) and Naoum (1998), a quantitative approach to this research was considered because it provides strong evidence for explaining phenomenon, enabling researchers to address the questions 'how much' or 'how many? More appropriately in the context of this investigation, this kind of research approach enables the researcher to establish 'which variables are significant and to what extent in a scientific way' (Walker, 1997). In line with the example of quantitative methods provided by Naoum (1998), this could be linked to the benefits of accident prevention as revealed in the literature such as improving productivity, improving chances of winning more contracts, improving corporate image, improving job satisfaction. The quantitative method therefore, is argued to be the best method to assess the true costs and associated benefits of accident prevention. Evidence from the literature on similar studies also suggests the quantitative approach to data collection (c.f Everret, 1996; Tang *et al.* 2004; Hammond, 2006).

Before turning to the data collection phase, the quantitative strategy or methods by which data on the research variables were gathered is described.

5.2.6 Design of the Survey Questionnaire

The questionnaire survey was designed primarily to elicit information from health and safety managers and similar personnel on costs and benefits of accident prevention so that the relationship between them could be explored using appropriate statistical techniques. These personnel were chosen because they are responsible for health and safety performance in the construction industry and are most knowledgeable on issues concerning health and safety performance. In view of the nature of the information needed, it was decided to design the questionnaire with both open-ended and closed-ended questions. Each of these formats has distinct advantages and disadvantages so combining them was essential in reducing or eliminating the disadvantage of each whilst gaining their advantages. The questionnaire, therefore, consisted of multiple choice questions (both dependent and independent variables) requiring ticked-box responses and open ended questions. Provisions were also made for respondents to contribute in free text forms any further comments or views they have in respect of each question.

Steps were taken to ensure that the designed questionnaire was 'respondent-friendly' (see Appendix C) in order to increase the rate of response, which is widely recognised as being particularly low in construction management research (Xiao, 2002; Ankrah, 2007). According to Babbie (1990), Fellow and Lui (1997) and Creswell (2003), it is well known that proper questionnaire design is vital for successful data collection. This was achieved by following recommended best practice advocated in the literature by, for example, Moser and Kaltron (1986); Oppenheim (1992); Devaus (2002) and Baker (2003). Such practice includes making sure the questionnaire was easy to read and understand, as short as possible and capable of completing within a matter of minutes and organised to follow smoothly without any hidden bias. Also, the wording of the questions was carefully considered to prevent as far as possible any confusion or ambiguity.

5.3 THE VARIABLES IN THE STUDY

A variable is any characteristic that can vary across people or situations that can be of different levels or type (Hammond *et al.* 2000; Burns, 2000; Creswell, 2003). There are two basic kinds of variables: dependent and independent (Creswell, 2003). These are independent and dependent variables.

The independent variable is that which the experiment manipulates or controls and as such is the variable in whose effect the researcher is interested while the dependent variable is the behavioural measure made by experimenter (Creswell, 2003). The independent variable in this study is the costs of accident prevention and the dependent variable is the benefit of accident prevention as outlined in Table 5.3. In the approach, the independent variable was compared to see its impact on the dependent variable. These variables were categorised into groups for comparison. The central goal was to obtain information on the dependent variable (benefits). Thus, by capturing data on these variables, data can be computed. Data on the variables are captured using purposively designed research instruments (Creswell, 2003).

Table 5.3: Dependent and Independent Variables

Dependent variable	**Independent variables**
Total benefits of accident prevention • Saving in insurance premiums; • Saving in litigation costs • Saving in sick costs • Improving production and productivity rates and lowering accident rates • Saving in sick pay cost • Saving in lost time of other employees cost; • Saving in overtime working cost • Saving in clean and waste disposal cost • Saving in temporary hiring of tools and equipment • Saving in working day lost cost • Productivity improvement • Image improvement	Costs of accident prevention • first aid facilities • PPE, • safety training • safety promotion • safety personnel salary • machinery/equipment

Source: Tang *et al.* (2004): HSE (2006); Ferret and Hughes (2007)

5.4 THE SURVEY INSTRUMENTS

Balnaves and Cupti, (2001) described the survey as a method of collecting data from people about who they are (education, finances), how they think, (motivations, beliefs) and what they do (behaviour). Babbie (1990) further described survey research as a way to generalise from a sample to a population so that inferences can be made about some characteristic, attitude, or behaviour of this population. It usually takes the form of a questionnaire that a person fills out alone or by interview schedule in person or by phone which is carried out through sampling.

5.4.1 Sampling Techniques in Research

Whichever research methodology is adopted for a specific research project, it is often not possible to study the whole population (Creswell, 2003). Therefore, samples have to be selected for the study. There are basically two types of sampling, which are probability (random) and non-probability (non-random) samples (Guba, 2000).

5.4.1.1 Probability/Random Sampling

Random sampling generally incorporates some type of systematic selection procedure to ensure that each unit or element has an equal chance of being selected. This does not, however, always guarantee a representative sample from the population.

5.4.1.2 Non-Probability/Non-Random Sampling

Non-random samples are mostly used in qualitative studies and market research, consulting with experts or for developing hypothesis for future research and in circumstances where adequate sampling frames are not available (Creswell, 2003). This type of sampling focuses on volunteer subjects, easily available potential subjects or those who just happen to be present when the research is carried out. There are no systematic selection procedures.

5.4.1.3 Selecting a Sample

Random sampling was the method adopted in this research. As indicated in Babbie (1990) and Creswell (2003), sampling is necessary because of the constraints of time and costs. The main advantage of this method is its ability to achieve reliability of measurements and also its ability to generalise about an entire population by drawing inferences based on data drawn from a small portion of that population (Rea and Parker, 1997). The greatest advantage is the relatively low cost associated with gathering of the data. The disadvantage is the data are unduly susceptible to time of measurement effects. The sample of respondents used in the survey was drawn from a database of contractors listed in the UK Kompass (2006) register. A total of 500 (small 35% n =175, medium 35% n =175 and large 30% n =150) were selected randomly across the UK and questionnaires were mailed out to participants for completion in this survey. The selection of the 500 samples is explained below.

According to DTI (2005), UK contractors exceed 176,000. However, it was not possible to collect data from all these contractors, therefore, sampling was necessary to make the survey possible. Following the examples of Soetano *et al*. (2001); Xiao (2002); Ankrah (2007), in order to determine a suitable size for the sample, the following formula from Czaja and Blair (1996) and Creative Research Systems (2003) as cited in Ankrah (2007) was applied.

$$SS = \frac{Z^2 + P\ (1-P)}{C^2}$$

Where SS = sample size

Z = standardised variable

P = percentage picking a choice expressed as decimal

C = confidence interval expressed as decimal

As with most other research, a confidence level of 95% was assumed (Munn and Drever, 1990; Creative Research System, 2003). For 95% confidence level (i.e. significance level of a = 0.05) Z = 1.96. Based on the need to find a balance between the level of precision, resources available and usefulness of the findings (Maisel and Persell, 1996), a confidence interval (C) of +_10% was also assumed for this research.

According to Czaja and Blair (1996) and Creative Research Systems (2003) as cited in Ankrah, (2007), when determining the sample size for a given level of accuracy, the worst case percentage picking (p) should be assumed. This is given as 50% or 0.5. Based on this assumption, the sample size was computed as follows:

$$SS = \frac{1.9^2 + 0.5(1-0.5)}{0.1^2} \qquad SS = 96.04$$

Therefore, the required sample size for the questionnaire is 96. However, this figure required a further correction for finite population. The formula for this was given in Czaja and Blair (1996) and Creative Research Systems (2003) as follows:

$$\text{New SS} = \frac{Ss}{1 + \frac{ss-1}{Pop}}$$

Where pop = population

$$\text{New SS} = \frac{96.04}{1 + \frac{96.04-1}{176000}} = 95.99$$

The sample size still remains approximately 96 contractors. This implies that if a sample size of approximately 96 is obtained, the data would be large enough for the sampling distribution to have a normal distribution. The UK construction industry is notorious for poor response to questionnaire surveys (Ankrah, 2007). Therefore, 20% - 30% is believed to be normal (Takim *et al.* 2004; Ankrah, 2007). Based on this reasoning, it was necessary to adjust the sample size to account for a high non-response rate. Assuming a conservative response rate of 20%, the appropriate sample to be calculated as:

$$\frac{\text{New SS}}{\text{Response rate}}$$

$$= \frac{96}{0.20} = 480 \text{ contractors}$$

Based on this, a total of 500 (large 30% n = 150, medium 35% n =175 and small 35% n = 175) contractors were selected randomly. Thus, individual contractors in the population had an equal probability of being selected. With randomisation, a representative sample from a population provides the ability to generalise to a population (Babbie, 1990). In addition, the exact number of contractors (population size) in this research is large and unknown. The mathematics of probability proves that the size of the population is irrelevant and can be ignored when it is "large" or unknown (Survey System, 2004 as cited in Cheng, 2008). Population size is only likely to be a factor when working with a relatively small and known group. This means that a sample of 500 is equally useful in examining the opinions of a population of 15,000,000 as it would a population of 100,000 (ibid) (c.f Cheng, 2008).

5.4.1.4 Administering the Survey

There are five strategies that the quantitative researcher can adopt to administer questionnaires (Frank, 1995; Nesbury, 2000). These are mail, fax, phone, web-based or internal surveys and personal face-face interview. The mail option was adopted and the questionnaires were sent through the post, which has the advantage of being cheap and easy to organise to cover a wider area. However, the advantages and disadvantages of each of the strategies are outlined in Table 5.4.

Table 5.4 Advantages and Disadvantages of Questionnaire Administration

Mail	Fax	Phone	Web-based	Face-face interview
Advantages: • Cost savings; • convenient; • ample times; • authoritative impressions; • anonymity; • reduced interviewer-induced bias. **Disadvantages:** • lower response rate than other method; • comparatively long time period; • self selection (never achieve 100% response rate); • lack of interviewer involvement; • lack of open-ended questions	**Advantages:** • faster when the interviewer and respondents have fax facilities **Disadvantages:** • the respondents might get annoyed when unwanted fax is used. • may not even complete the questions	**Advantages:** • rapid data collection; • lower cost; • anonymity; • large scale accessibility; • assurance that instructions are followed. **Disadvantages:** • less control; • less credibility; • lack of visual materials; • limited potential respondents. • more expensive	**Advantages:** • faster availability of data through the simplification of data entry and editing; • better data quality; • more user-friendly than the paper questionnaire **Disadvantages:** • automatic filtering of irrelevant survey items.	**Advantages:** • flexibility; • greater complexity; • ability to contact hard–to–reach population; • high response rate; • assurance that instructions are followed. **Disadvantages:** • high cost; • interview induced bias; • respondents' reluctance to co-operate; • greater stress; less anonymity; • concern about personal safety.

Source: Creswell (2003)

5.5 RESEARCH DESIGN

The basic reasoning underpinning the research design is the concept of analytical generation (Yin, 1989 and Antwi, 2000) as cited in Egbu, (2007). Under this approach, a study was conducted in a typical case study area and the general conclusions reached were applied to the particular area. The case study was in the UK which covered all the regions in order to have a truly represented active picture of the situation by capturing data from a broader geographical area. A questionnaire was initially prepared and an initial pilot survey was then conducted to test the suitability and comprehensibility of the questionnaire. Following Oloke (2003), a methodology was formulated as shown in Figure 5.1

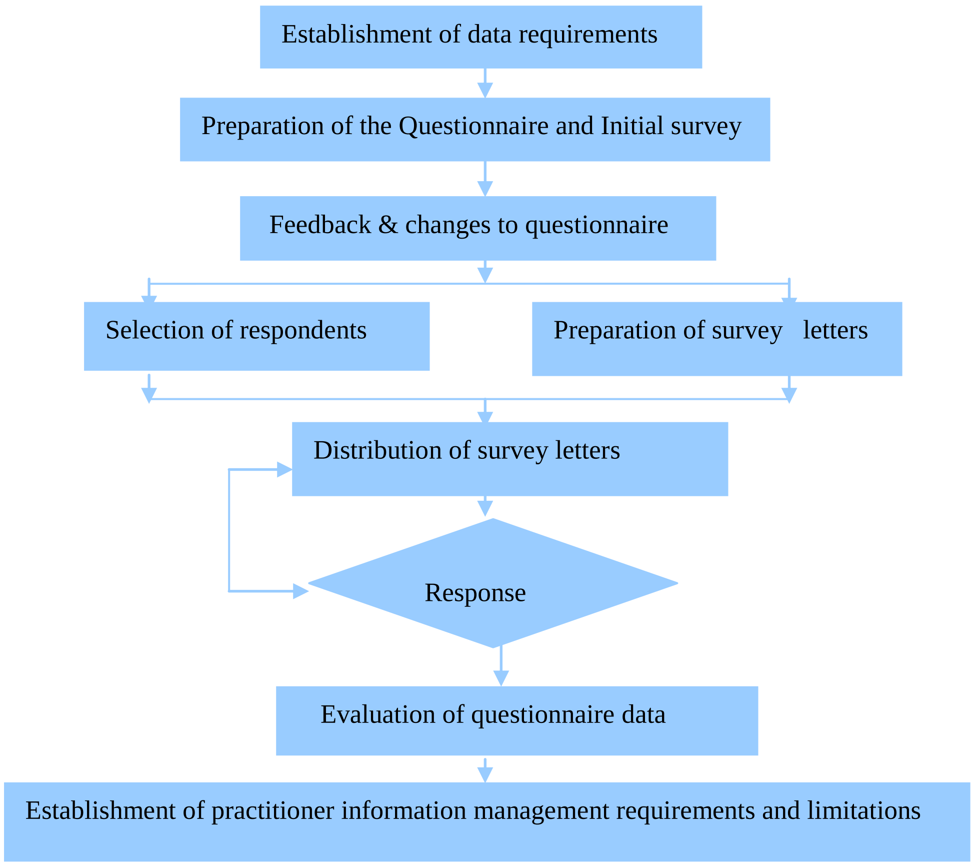

Figure 5.1: Flowchart of Pilot Study Methodology

Source: Adapted from Oloke (2003)

5.6 PILOT STUDY

In order to evaluate the clarity and comprehensiveness of the questionnaire, as well as the feasibility of the survey as a whole, a pilot survey was conducted prior to the major survey. The aim of the pilot study was to test the wording of the questionnaire, identify ambiguous questions, test the intended technique for data collection and measure the effectiveness of the potential response (Creswell, 2003). Bell (1996) as cited in Ahadzie (2007) described pilot study as a trial run that can help the researcher to smoothen out the survey instrument to ensure that the participants in the main survey experienced no difficulties in completing it. As argued by several researchers like Munn and Drever (1990), such test run surveys are necessary to demonstrate the methodological rigor of the survey. The survey sample used in the pilot survey was drawn primarily from a database of contractors in the UK Compass (2006) Directory and also included participants who had earlier conducted notable research on health and safety for HSE.

5.6.1 Respondent Characteristics

A total of 30 organisations were sent out questionnaires randomly as part of the pilot survey and 6 (six) were returned representing a response rate of 20%. This compared favourably with the 20% response rate achieved in the pilot survey reported in Xiao (2002). Of the respondents, 3% represented large contractors, 7% represented medium and 10% represented small. It is worth noting that the 6 (six) participants identified for the pilot study were thereafter not included in the main survey. The pilot questionnaires were sent through mail with a covering letter explaining the purpose of the pilot study (see Appendix A). The respondents were asked in this letter to appraise critically the questions and provide feedback as to their relevance and sensitivity and to offer any suggestions for improvement. The data collection exercise for the pilot survey was conducted from June, 2007 to July, 2007.

5.6.2 Feedback

Within a period of one month, all completed questionnaires were retrieved. The feedback came from 1 (one) civil engineering and building contractor, 3 (three) house builders and well-experienced construction health and safety practitioners, including renowned researchers such as Carpenter, the author of HSE, 2005 Research Report 422 and Andy Chappell, Secretary BHSEA (two consultancy) as further shown in Figure 5.1.

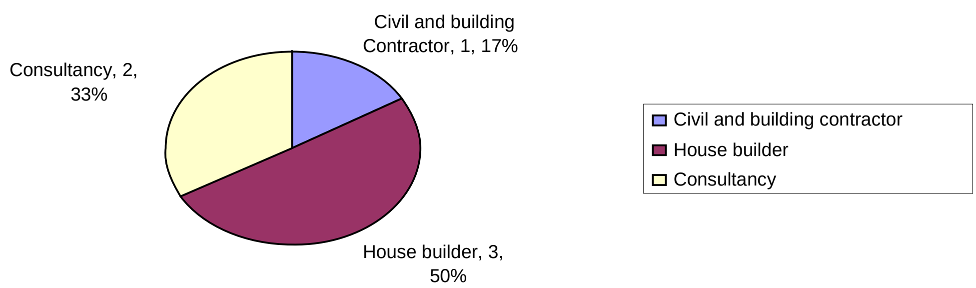

Figure 5.2 Pilot questionnaire responses

Their feedback, which were in the form of comments and suggestions were very helpful in clarifying a number of issues concerning the research questions to be addressed in the study. Some of the key comments/suggestions offered included the following:

(i) They commented that historical records on costs of accident prevention are not kept for more than two years.

(ii) In response to the question of what general comment they could offer to improve

the research, they suggested that it would be better to restrict the data to costs of accident prevention incurred and benefits of prevention accrued in the last 12 (twelve) months for respondents to feel more comfortable and confident to answer the questionnaire.

(iii) It was also suggested that it would be a good idea to adopt postal questionnaire

with indication that general information sought be made optional. This would yield more positive results than face–face interviews or telephone interviews because of the sensitive and confidential nature of the questionnaire and of the information being sought.

It was believed that some organizations might not want to be identified, as it was likely to affect their image and possibly lead to losses such as chances of winning more contracts. This would make them confident to give necessary information about their costs. As a result, the study took a decision to adopt a postal questionnaire rather than face–face interview and telephone interview as suggested.

The pilot study was therefore a useful exercise, particularly with regard to gathering information on issues such as questions asked and their relevance to construction health and safety management in the UK. This helped to sharpen the final version of the questionnaire for the main survey. Following this study, the main questionnaire was modified based on the feedback received; some questions were amended or removed altogether and some news ones added depending on which were deemed appropriate and applicable as recommended by the respondents.

5.7 MAIN QUESTIONNAIRE DESIGN

The wording of the questionnaire was reviewed as suggested in the pilot study to ensure that the questions were easily readable and appealing to the respondents. The layout and format of the questionnaire was also given much consideration to maximize response and to ensure that respondents did not miss questions. This step was taken to encourage respondents to tick the appropriate figure that applies to their organisation. In order to encourage a good response, the questionnaires were mailed out with an accompanying personalised, signed cover letter and a self-addressed envelope. Another step that was taken to maximise response involved mailing out a second set of questionnaires to all the non-respondents three weeks after the first mail shot as recommended by Creswell (2003). This was undertaken in the same way and manner as the first mailings was carried out but making a special appeal to them this time for their assistance. The data collection exercise was conducted from September, 2007 to January, 2008 and was followed by data analyses.

5.8 DATA ANALYSES

The main analysis of survey data was undertaken using the Statistical Package for the Social Sciences (SPSS). This involved deriving descriptive statistics (frequency tables), ratio analysis and, subsequently, conducting correlation and regression analysis on quantitative data.

5.8.1 Descriptive Analysis

Descriptive analysis was conducted on the data for the subordinate variables. Based on this analysis, the most typical values (mean, median and mode) were adopted. Descriptive analysis is a way of describing a particular situation or event (Reaves, 1992). It is an aspect of statistics, which allows researchers to summarise large quantities of data using measures that are easily understood by an observer (Burns, 2000). Descriptive statistics summarised raw scores, e.g. average, percentage, variance (Hammond *et al.* 2000). The results of the descriptive statistics were presented, categorised by organisation size using DTI (2005) definition of organisation size of contractors. Mostly, the results were presented as a percentage of the total respondents or respondents that answer a particular question. At this stage it could not explain the situation or predict what it might be in the future or how it might change.

5.8.2 Ratio Analysis

To obtain insight into costs and benefits, the basic data was converted into ratio analysis for the purpose of ratio analysis only. Ratio is defined as a relatively crude diagnostic tool which can help managers and investors identify the strengths and weakness of a company (Moh, 1999). Blaikie (2003); King (2003): Pizzey (1994) described ratio as just a comparison between two different things or between one and another which can be expressed as a fraction or a percentage. The ratio aspect was introduced so that both costs and benefits of accident prevention could be compared as fraction or percentage (cf. Tang *et al.* 2004).

Successful Use of Ratio Analysis

Ratio analysis can be used to check the profitability and efficiency of business and also the liquidity (King, 2003). This means ratio analysis can be used to know or compare costs of accident prevention and benefits of prevention. Glautier and Underdown (2001) emphasised that ratio analysis provides the most commonly used indicators to assess and compare the financial performance of companies. Thus, the ratio analysis can be related to the amount of contractor's turnover to the construction health and safety performance. From ratio, as argued by McKenzie (2003), it is possible to tell whether companies are underperforming. This suggests that it can be used to appraise the performance of contractors in terms of health and safety measures. For instance, accountants often use ratios to focus attention on important items in accounting statements or to illustrate points made in reports. As noted by Pizzey (1994), absolute figures in an accounting statement are made more meaningful when they are put into perspective by comparison. Therefore, ratio was adopted in this research to obtain insight into the costs and benefits of accidents prevention and to provide a uniform basis for comparing the costs as well as the benefits of accident prevention across the three sizes of contractors when turnover was taken into account.

The ratios were calculated by dividing the turnover by the relevant costs or benefits as follows (c.f Blaikie, 2003).

$$R = \frac{T}{Y_i}$$

R = Ratio

T = Turnover

Y_i = i^{th} cost or benefit.

This approach was applied to the data to establish the comparative economic costs and benefits of accident prevention across the various categories of contractors.

5.8.3 Correlation Analysis

Correlation analysis is a means of measuring the strength or 'closeness' of the relationship between two variables (Fleming & Nellis, 1994). Correlation indicates both the strength and the direction of the relationship between a pair of variables (Bryman and Crammer, 1999) and is a very common statistic tool in construction research. Some examples of research that have utilised this technique include Hammond (2006), Egbu (2007), Ahadzie (2007) and Ankrah (2007). The strength and direction of the relationship is assessed by reference to a correlation coefficient (r) which according to Field (2005) is calculated as follows:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{(N-1)s_x s_y}$$

where

S_X is the standard deviation of the first variable

S_Y is the standard deviation of the second variable.

x_i and y_i are the data points in question

$\bar{x}$ and $\bar{y}$ are the means of the sample

N is the number of observation

The coefficient (r) in the equation is known as the Pearson correlation coefficient. Pearson correlation coefficient is the most useful correlation statistic (Frees, 1996). It is a measure of the linear relationship between two variables (Field, 2005). In SPSS, this coefficient is produced together with its significance level. If the correlation coefficient is 0, then the two variables do not vary together at all. If the correlation coefficient is positive, the two variables tend to increase or decrease together. If the correlation coefficient is negative, the two variables are inversely related, that is, as one variable tends to decrease, the other tends to increase. If the correlation coefficient is 1 or -1, the two variables vary together completely, that is, a graph of the data points forms a straight line (Motulsky, 1995). The significance level helps to establish which coefficients are significant and which are not. In the social sciences, significance levels less than 0.05 are considered indicative of genuine relationships which are not just due to chance (Field, 2005).

5.8.4 Regression Analysis

Generally, regression analysis is a statistical technique that helps determine the proportion of variance in, preferably normally distributed dependent variable, accounted for by one or more independent variables (Creswell, 2003). Simple linear regression was adopted to explore the relationship between costs and benefits of accident prevention. It was anticipated that the results of the linear regression model would reveal how well costs of accident prevention predict the benefits.

Regression analysis is usually concerned with the derivation of an equation which defines a best-fitting regression line (Fleming & Nellis, 1994). The equation is in the form of:

$$Y_i = (\beta_0 + \beta_1 X_i) + \varepsilon_i$$

Where:

Y_i = the outcome variable (dependent)

β_0 = the value of the outcome when the predictor is zero

β_1 = the regression coefficient of the first predictor X_i

ε_i = the difference between the predicted and observed value

The coefficient (β_1) provides the magnitude of the unique contribution that the independent variable makes to the dependent variable. This makes the simple linear regression particularly appropriate in this research which seeks to examine the influence of costs of accident prevention (independent variable) on benefits of accident prevention (dependent variable).

Two research questions will be addressed in this model.

1. What is the correlation between costs and benefits of accident prevention?
2. What impact do costs of prevention have on benefits of prevention to contractors?

In evaluating the costs of accident prevention, there was recourse to employ analysis of variance (ANOVA). Analysis of variance (ANOVA) or F-test is parametric statistical technique for determining whether the variance in quantitative variables differ significantly from that expected by chance (Creswell, 2003). This can be achieved by testing whether the samples drawn come from the populations with equal mean, by comparing the means of the samples. The means are indirectly examined using the estimates of population variances instead (Black, 1999). ANOVA is a hypothesis testing procedure used to determine if mean differences exist for two or more samples or treatment (Burns 2000). The purpose of ANOVA is to decide whether the differences between samples is simply due to chance (sampling error) or whether there are systematic treatment effects that have scores in one group to be different from scores in other group (Creswell, 2003).

5.9 MISSING DATA

Missing data is not uncommon and was expected in the research. Some respondents failed to answer all the questions contained in the questionnaires. However, different imputation methods exist for missing data; including case substitution, mean substitution, cold deck imputation, regression imputation and multiple imputations (Hair *et al.* 1998). Mean substitution is one of the more widely used methods as the mean is considered the best single replacement value (Hair *et al.* 1998). The SPSS V.12 missing value analysis option was used to analyse the patterns of missing data. This approach was adopted in this research for replacing missing data before analysing data for the affected variables.

5.10 ETHICAL CONSIDERATIONS

Ethical consideration is a concern to any researcher and any good institution that conducts research. According to a dictionary definition, to be ethical is to conform to accepted professional practices (Webster, 1968 cited in Bailey, 1987). In conforming to the established trend, the University of Wolverhampton (UoW) put in place a rigorous ethical validation procedure to assist researchers conform to a reasonably accepted standard. Among others, the code designed by the UoW is to ensure that:

- There is no interference with participants' physical and psychological well-being;
- The research procedure is not likely to be stressful or distressing;
- The research materials are not sensitive, discriminatory or inappropriate;

- The research design is sufficiently well-grounded so that the potential participants' time is not wasted during the data collection.

The research instruments used for this study were therefore subjected to UoW ethical research committee approval before embarking on the field data collection. In order to conform to the ethical norm, the issue of confidentiality was addressed in the accompanying introductory letter to participants. Participants were informed about who would have access to the material from the survey and how the research findings would be disseminated. Confidentiality was addressed by ensuring the anonymity of the individual participants. Thus, consent of respondents was obtained. Information was provided about the purpose of the survey and potential benefits of the study to the construction industry.

5.11 SUMMARY

The Chapter has presented a detailed outline of the research methodology adopted for undertaking this research. The adopted research method was largely the quantitative method. This was chosen based on the evidence from the literature and on the need to obtain quantitative measures for analysis. A quantitative approach to this study was considered appropriate to determine the quantitative nature of the relationship between the costs and the benefits of accident prevention. Arguments were presented justifying this choice of approach and the specific research methods applied to collect data. The sample survey approach was also adopted to obtain data for analysis. The data collection process was detailed in this chapter. The next chapter, (i.e. chapter 6) presents the first part of the data analysis on cost and benefit of accident prevention.

CHAPTER 6

PRELIMINARY DATA ANALYSIS

6.1 INTRODUCTION

Having formulated the CBA framework (see chapter 4) and described the research methodology employed in this study (see chapter 5), this chapter now presents the preliminary findings obtained from the field survey. This chapter, and the next, addresses the research questions of the thesis raised in chapter 1. The analysis presented here is a prelude to their substantive analysis (see chapter 7). The chapter reports information regarding the response rate and characteristics of the contractors captured in the survey, followed by descriptive statistics and ratio analysis of both the cost and benefits of accident prevention. The descriptive statistic encompassed frequency distribution, measures of central tendency such as means, medians, modes and measures of dispersion. These were employed to develop a generalised view of the data. The ratio analysis provided a uniform basis for comparing the costs as well as the benefits of accident prevention across different categories of contractors. The comparison made it possible to rank the extent to which each contractor was affected in terms of costs and benefits of accident prevention in the UK construction industry when turnover was taken into account.

6.2 ANALYSIS OF RESPONSE RATE

To recapitulate, a total number of 500 questionnaires were distributed to contractors in the UK construction industry. Achieving the target spread across different categories of contractors proved to be more difficult than expected, especially among the largest and medium contractors. A total of 79 questionnaires were received from the target sample. This represents 15.8% total response rate as shown in Table 6.1.

Table 6.1: Main Survey Response Rate

Date	Amount distributed	Amount retrieved	percentage
4/09/07	200	34	17%
12/10/07	200	27	13.5%
18/11/07	100	18	18%
Total	500	79	15.8%

It was reported in Takim *et al.* (2004) that the response rate norm for postal questionnaire surveys is 20–30%. Other sources that support this view include Black *et al.* (2000) which reported a response rate of 26.7% for a questionnaire survey conducted stating that response rates in this region in construction surveys are not unusual at all. Although, the response rate obtained in this survey appears to be low compared to the standard response rate norm for postal questionnaire, indeed, lower response rates in the region of 14.7% (Soetanto *et al.* 2001) have been described as the 'norm' for comprehensive questionnaires. Sutrisna (2004) even reported a response rate of 8.8% and Ankrah (2007) achieved a response rate of combined pilot and main survey of 15.42%. Indeed, owing to the sensitive nature of the research, a response rate of 15.8% can be considered adequate.

To assess the reasons why potential respondents did not complete the form, some of the non-respondents were contacted on the phone after two follow up letters of appeal. Ten Health and Safety Managers/Safety Personnel Officers said they did not have the required data, and ten others claimed the information was too confidential. Based on this information, a third round of follow up letters of appeal with explanation of the questionnaire were mailed out, which yielded additional 18 responses as shown in Table 6.1 (see column 3 row 4). A period of up to 4 months was allowed for the completed questionnaires to be retrieved. After several efforts to improve the response rate, when the period projects have expired, survey instruments not retrieved were declared non-responsible. Thus, within a 4 month period, all retrieved surveyed instruments were put together.

As stated in chapter 5 section 5.2.6, the Health and Safety managers were targeted in the questionnaire as the main respondent because it was hoped that, by the nature of their role, they were better placed and presumably abreast with detailed knowledge and understanding of the costs of accident prevention to their respective organisations as well as the benefits of accident prevention. They were, thus, most likely to offer more reliable and informed responses to the questions posed in the research instruments. This presumption converges with the contention of Borman (1978) that people who are suitably experienced in what they do should be in a better position to provide relatively accurate responses.

Table 6.2 summarises the respondents' number of years of experience within the UK construction industry. According to the table, about 25% have less than five years experience (see column 1 row 2) and about 75% (see column 2, 3 & 4 row 2) of the respondents in this study have more than five years experience as health and safety managers in the UK construction industry.

Table 6.2 Respondent Number of Years of Experience

No of years	< 5 years	6 – 10 years	11 – 25 years	>25 years	Total
% response rate	24.6	47.8	17.5	10.1	100
Number	19	38	14	8	79

These results indicate that the respondents have reasonable experience in implementing health and safety in the UK construction industry. It further shows that the respondents are sufficiently experienced to provide data which are credible. Table 6.2 also shows that of those who responded, all the organisations have someone who is responsible (or knowledgeable) for health and safety management to rigorously implement health and safety in their respective organisations.

6.3 CHARACTERISTICS OF CONTRACTORS IN THE SAMPLE

To provide a context within which the findings of the survey and subsequent analyses can be taken as valid and to ensure that any inferences extended to the population from this sample are valid, various characteristics of contractors were elicited in the questionnaire survey. These characteristics, including construction sector, contractor size (based on number of employees) and turnover, are now discussed to provide a profile of the sample.

6.3.1 Construction Sector

Question number A2 (see Appendix C) under the general information section of the questionnaire asked the respondents to indicate the main construction sector in which their organisations have business activity. Table 6.3 provides a breakdown of the contractors, the number of responses from each of the construction sector, and the nature and percentage distribution across the construction sectors. From Table 6.3, it can be seen that the contractors surveyed have business activities in seven main construction sectors in the UK.

Table 6.3 Construction Sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	civil engineering contractor	13	16.5	16.5	16.5
	Building contractor	37	46.8	46.8	63.3
	specialist subcontractor	3	3.8	3.8	67.1
	House builder	5	6.3	6.3	73.4
	Consultancy	4	5.1	5.1	78.5
	Building and Civil engineering contractor	8	10.1	10.1	88.6
	Demolition	5	6.3	6.3	94.9
	Other (please specify	4	5.1	5.1	100.0
	Total	79	100.0	100.0	

The results show that the building contractor sector returned the highest number of respondents with response rate of about 47% (n = 37), followed by civil engineering contractors with about 17% (n = 13), building and civil engineering contractor 10% (n = 8), house builder 6% (n = 5), demolition contractor 6% (n = 5), consultancy about 6% (n = 4), other contractors about 5% (n = 4) and specialist contractor 4% (n = 3). This outcome showing building and civil engineering contractors as the largest sectors is not unexpected, given that these have been described (together with house building) as the main sectors in the UK construction industry (BERR, 2007). However, it should be noted that each sector were not identified at the sending out point because the contractors were only selected randomly. Contractors were only asked in the main questionnaire to indicate the type of construction organisation their company belongs to identify each sector. It can be concluded, therefore, that the sample reflects the reality.

6.3.2 Size of Contractors

In the questionnaire, respondents were asked to indicate the number of employees in their organisation, in order to identify small, medium and large contractors. Table 6.4 below presents the results of the descriptive analysis of the responses to this question. From the results of the survey as shown in Table 6.4 above, 33 (42%) are small contractors, followed by 25 (about 31%) large contractors and 21 medium contractors (about 27%).

Table 6.4 Size of Contractors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 - 49 = Small contractors	33	41.8	41.8	41.8
	50 - 249 = Medium contractors	21	26.6	26.6	68.4
	>250 = Large contractors	25	31.6	31.6	100.0
	Total	79	100.0	100.0	

Since the questionnaires were distributed to randomly selected contractors, it was expected that the largest number of respondents would be small contractors followed by medium contractors and finally large contractors, in line with the profile of the UK construction industry (Ashworth, 2005). This profile was not fully reflected in the results obtained. Even though small contractors did constitute the largest block of respondents, they were not followed by medium and then large contractors in that order. Whilst the reasons for this outcome are not clearly apparent, it can be seen that all categories of contractors are represented in the data collected and, therefore, inferences drawn from this data can be extended to the population.

6.3.3 Turnover

In the questionnaire, respondents were asked to indicate the annual turnover of their organisation (refer Table 6.5 below). Whereas about 39% (n = 31) indicated an annual turnover of less than £5m, 24% (n = 19) indicated an annual turnover of between £5m – £25m and about 37% (n = 29) indicated an annual turnover of over £26m. This annual turnover can also be used as a basis for categorising contractors into small (< 50 employees), medium (50 – 249 employees) or large companies (> 250 employees) (cf. DTI, 2005). By way of the DTI (2005) definition, annual turnover of < £5m suggests a small contractor, whereas annual turnover in excess of £26m suggests a large contractor.

Table 6.5 Turnover

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< £5M	31	39.2	39.2	39.2
	£6M-£10M	9	11.4	11.4	50.6
	£11 - £25M	10	12.7	12.7	63.3
	£26m - £100M	8	10.1	10.1	73.4
	>£100M	21	26.6	26.6	100.0
	Total	79	100.0	100.0	

As shown in Table 6.5 above, small contractors with turnover of less than £5m constituted 39%. Large contractors were about 37%, and the medium contractors were just about 24% of the sample. Clearly, this reinforces the categorisation of the contractors on the basis of the number of employees and turnover, and underpins the validity of the data.

6.3.4 Cost of Accidents

To establish contractors' cost of accidents, respondents were asked to indicate the costs incurred following accidents (see section B2 in Appendix C). To ensure comparability, these costs have been expressed as a ratio of the turnover and results are summarised in Table 6.6 below. The minimum value was found to be £3,598 and the maximum to be £1,490,917. This means that the wide range of costs being incurred by contractors reflects the rate of accidents on construction projects. From Table 6.6, because the standard deviation is rather large and the result of the test of normality using Kolmogorov-Smirnov shown in Table 6.7 indicates that it is not normal, the median is therefore, used as the best measure of central tendency (Field, 2005), which in this case is £60,000. The size of this standard deviation clearly shows that the mean does not represent a good model of the survey data (Field, 2005).

Table 6.6 Turnover to Total Costs of Accidents

Statistics

Totalturnovercost

N	Valid	79.00
	Missing	.00
	Mean	220103.85
	Std. Error of Mean	40156.55
	Median	60000.00
	Mode	60000.00
	Std. Deviation	356919.27
	Minimum	3598.78
	Maximum	1490917.36

From the test of normality using Kolmogorov-Smirnov as shown in Table 6.7, P- value < 0.05 indicates a deviation from normality. This test confirms that K-S is highly significant. According to Field (2005) it shows that the mean is not an accurate representation of the data. Field (2005) and Mann (2003) suggested that in cases like this, the median is preferable. Therefore, the median values are used as the measure of central tendency as shown in Table 6.7

Table 6.7 One-Sample Kolmogorov-Smirnov Test Statistics

		Totalturnovercost
N		79
Normal Parameters[a]	Mean	220103.8517
	Std. Deviation	3.56919E5
Most Extreme Differences	Absolute	.318
	Positive	.318
	Negative	-.272
Kolmogorov-Smirnov Z		2.828
Asymp. Sig. (2-tailed)		.000

a. Test distribution is Normal.

Further more, to determine which size of contractors incurred higher costs of accident; Kruskal-Wallis test is used. Kruskal-Wallis is a non parametric test of whether more than two independent groups differ (Field, 2005). It is the non parametric version of one way independent ANOVA that is used in non-normally distributed data. The theory of the Kruskal-Wallis test is very similar to that of the Mann-Whitney (and Wilcoxon rank-sum) test. Like Mann-Whitney test, the Kruskal-Wallis test is based on ranked data.

From Table 6.8, when these costs are compared across different categories of contractor's size, it can be seen that large contractors have higher costs of accidents (52) than medium (42) and small (30) contractors. Based on their median expenditure on accident costs, it can be argued that large contractors have more costs of accidents than medium contractors who also have more costs of accidents than small contractors. This finding is not unexpected as research has already established that because of the relatively higher numbers of employees large contractors usually have more accidents than medium and small contractors (Lancaster *et al.* 2003).

Table 6.8

Kruskal-Wallis Test

Ranks

	Size of contractors	N	Mean Rank
Totalturnovercost	0 - 49 = Small contractors	33	29.76
	50 - 249 = Medium contractors	21	41.81
	>250 = Large contractors	25	52.00
	Total	79	

Table 6.9 Test Statistics[a,b,c]

	Total turnover cost of accidents
Chi-Square	13.618
df	2
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Size of contractors

c. Some or all exact significances cannot be computed because there is insufficient memory.

In other to relate this to the number of employees and manhour, the median value in Table 6.10 is used.

Table 6.10 Number of Employees

Statistics		
Number of employees		
N	Valid	79.000
	Missing	.000
	Mean	555.456
	Std. Error of Mean	143.400
	Median	59.000
	Mode	40.000[a]
	Std. Deviation	1274.569

a. Multiple modes exist. The smallest value is shown

To put these in proper context, the number of manhours for which these results applied are considered, which is based on an estimated median value of number of employees, X basic annual employee's hours (1871hrs) as calculated by Chartered Institute of Building (CIOB, 1997).

Estimated average manhour = median (number of employees) X basic annual employee's hours = 59 X 1871 = 110389

This means that for the 79 cases the costs of accident was £60,000 per 110,389manhours.

The foregoing discussions demonstrate that the survey has covered the full range of contractors of different sizes and turnover, and with different levels of costs in respect of accidents. All the main sectors in construction are also represented in the sample. This, therefore, provides a context within which the subsequent analyses and findings can be taken as valid. Having provided a profile of the contractors in the sample, the discussion below focuses on the economic costs and benefits of accident prevention. To foster deeper understanding, each of the elements is discussed in turn.

6.4 ECONOMIC COSTS OF ACCIDENT PREVENTION

As noted in chapter 2, the cost of accident prevention is the costs of resources spent by contractors in implementing health and safety measures in order to comply with their health and safety obligations. It refers to measures that contractors are required by policy to put in place. It can be argued that its rigorous implementation should lead to reduced rate of accidents on construction sites and, consequently, improvement of production and productivity, work motivation, personal relationships in the worksite, and improvement of the corporate image of the organisation.

To assess the levels of implementation of health and safety measures across the different categories of contractors in the sample, and to ensure that the comparisons are made on the same basis and reflect the different turnover levels, ratios were employed in the analyses of the data. As stated in chapter 5 section 5.8.2, ratios are just a comparison between two different things or between one and another and can be expressed as a fraction or a percentage (Pizzey, 1994; Blaikie, 2003; King, 2003). It has also been defined as a relatively crude diagnostic tool which can help managers and investors identify the strengths and weakness of a company (Moh, 1999). Ratio analysis provides the most commonly used indicators to assess and compare the financial performance of companies (Glautier & Underdown, 2001). Typically, it is used to check the profitability and efficiency of business and also the liquidity of the company relative to another company (King, 2003; McKenzie, 2003). Its function is to provide a common basis on which comparison can be made. Thus, it can be used to guide contractors in their decision making to compare costs and benefits of accident prevention

Relating this to the construction health and safety context, different sizes of contractors expend different amounts on accident prevention and derive different levels of benefits from these expenditures. In order to provide a common basis for comparing contractors, ratio analysis provides a convenient means of relating such costs and benefits to turnover so that the confounding effect of company size is nullified. In the subsequent analyses, therefore, all the costs and benefits of accident prevention are related to the amount of contractor's turnover. From these ratios it is possible to tell which size of contractors are expending more resources on accident prevention and which size of contractors are deriving the most benefits from such expenditure.

The full results showing the comparative economic costs of accident prevention are presented in Appendix E Table 1. Before turning to Table 6.11, it is important to explain how these Tables in appendix E were derived. They were derived from SPSS and analysed base on the size of contractors i.e. small (< 50), medium (>50 < 250) and large (> 50) and ratio of turnover to each of the respective variables using custom table. From Appendix E Table 1, it can be seen from the large standard deviations that the data is widely dispersed. Therefore, the median values are used as the measure of central tendency. These median values are summarised in Table 6.11.

Table 6.11: Costs of Accident Prevention Ratio

Contractor	$\mathbf{T/Y_{first\ aid}}$	$\mathbf{T/Y_{PPE}}$	$\mathbf{T/Y_{Promotion}}$	$\mathbf{T/Y_{Training}}$	$\mathbf{T/Y_{personnel}}$	$\mathbf{T/Y_{Total\ cost}}$
Small	5000.00	5000.00	5000.00	454.59	454.59	143.87
Medium	3273.02	1454.68	3273.02	600.01	600.01	170.22
Large	3333.39	2100.04	3333.39	800.00	800.00	241.96
Total	5000.00	2100.03	5000.00	600.01	600.01	205.97

6.4.1. Cost of First Aid

From Table 6.11 it can be seen that across the sample, for every £5000.00 (see column 2) of turnover, £1.00 (0.02%) is spent on first aid facilities. Comparatively, small contractors spend £1.00 out of every £5000.00 (see column 2) turnover (0.02%) whilst medium and large contractors spend identical proportions of £1.00 out of every £3,273.00 (see column 2) (0.03%) and £3333.39 (see column 2) (0.03%) turnover, respectively. Therefore, based on these results small, medium and large contractors can be said to spend similar proportions of their turnover on first aid facilities

6.4.2 Cost of PPE

From Table 6.11 it can be seen that across the sample, for every £2100. 00 (see column 3) of turnover, £1.00 (0.05%) is spent on PPE. Comparatively, small contractors spend £1.00 out of every £5000.00 (see column 3) turnover (0.02%) whilst medium and large contractors spend higher proportions of £1.00 out of every £1454.68 (see column 3) (0.07%) and £2100.04 (see column 3) (0.05%) turnover respectively. It can be inferred from these results that small contractors spend relatively less on PPE than medium and large contractors, whilst medium contractors spend a larger proportion of their turnover on PPE than large contractors.

6.4.3 Cost of Safety Promotion

From Table 6.11 it can be seen that across the sample, for every £5000.00 (see column 4) of turnover, £1.00 (0.02%) is spent on safety promotion. Comparatively, small contractors spend £1.00 out of every £5000.00 (see column 4) turnover (0.02%) whilst medium and large contractors spend identical proportions of £1.00 out of every £3,273.00 (see column 4) (0.03%) and £3333.39 (see column 4) (0.03%) turnover respectively. Hence, based on these results small, medium and large contractors can be said to spend similar proportions of their turnover on safety promotion.

6.4.4 Costs of Safety Training

From Table 6.11 it can be seen that across the sample, for every £600.01 (see column 5) of turnover, £1.00 (0.17%) is spent on safety training. Comparatively, small contractors spend £1.00 out of every £454.59 (see column 5) turnover (0.22%) whilst medium and large contractors spend identical proportions of £1.00 out of every £600.01 (see column 5) (0.17%) and £800.00 (see column 5) (0.13%) turnover respectively. It can be inferred from these results that small contractors spend relatively higher proportions of their turnover on safety training than medium and large contractors, and medium contractors spend a higher proportion of their turnover on training than large contractors.

6.4.5 Costs of Health and Safety Personnel Salary

From Table 6.11 it can be seen that across the sample, for every £600.01 (see column 6) of turnover, £1.00 (0.17%) is spent on safety personnel. Comparatively, small contractors spend £1.00 out of every £454.59 (see column 6) turnover (0.22%) whilst medium and large contractors spend identical proportions of £1.00 out of every £600.01 (see column 6) (0.17%) and £800.00 (see column 6) (0.13%) turnover respectively. It can be inferred from these results that small contractors spend relatively higher proportions of their turnover on safety personnel than medium and large contractors, and medium contractors spend a higher proportion of their turnover on personnel than large contractors.

6.4.6 Turnover to Total Costs of Accident Prevention Ratio

From the median values shown in Table 6.12, it can be seen that small contractors spend £1.00 out of every £143.87 (see column 2) turnover (0.69%) whilst medium and large contractors spend identical proportions of £1.00 out of every £170.22 (see column 3) (0.59%) and £241.96(see column 4) (0.41%) turnover, respectively. It can be inferred from these results that small contractors spend relatively higher proportions of their turnover in total on accident prevention than medium and large contractors, and medium contractors spend a higher proportion of their turnover in total on accident prevention than large contractors.

Table 6.12 Total Costs of Accident Prevention Ratio

Preventive measures	Small	Medium	Large
First aid	5000.00	3273.02	3333.39
PPE	5000.00	1454.68	2100.04
Promotion	5000.00	3273.02	3333.39
Training	454.59	600.01	800.00
Personnel	459.54	600.01	800.00
T/Y Total cost of accident prevention ratio	143.87	170.22	241.97

According to the literature (refer to chapter 2) there is widespread belief that large contractors spend more on accident prevention. From Tables 6.12, it is indicated that large contractors spend more on health and safety measures than the medium and small contractors because of their size but not as a ratio of turnover than medium and small contractors. The findings on their relative expenditures (as a direct proportion of turnover), however, appears to contradict this belief. Indeed, this finding rejects the null hypothesis, which stated that large contractors spend more percentage of their turnover on health and safety measures than small and medium contractors. Therefore, the alternative hypothesis is accepted. There is enough evidence from the above statistics to support the alternative hypothesis and hence the null hypothesis is rejected. Although in terms of the actual expenditure large contractors spend more than medium or small contractors but not as a ratio of turnover, clearly small contractors are spending more (as a proportion of their turnover) on accident prevention than medium and large contractors, with the large contractors spending the least.

What is further evident on Table 6.12 is that different company size categories of contractors place similar emphasis on the different measures required for accident prevention. For instance, all three categories of contractors (small, medium and large) spend higher proportions of their turnover on safety training and personnel salaries than PPE, first aid facilities and safety promotion. This may indicate an awareness or belief among contractors of all sizes that safety training and safety personnel are the two most effective measures for accident prevention. This seems to suggest that the levels of awareness of hazards, risks and accident prevention strategies, as well as the personnel to monitor safety are considered by contractors to be most critical to accident prevention on construction projects. There is merit to this conclusion given the knowledge that most accidents occur as a result of human error (c.f Aston, 1998; Abdelhamid and Everret, 2000), with the role of training being to raise consciousness so that human error can be minimized and the role of personnel being to monitor the activities of workers and conditions on site so that hazards and potential human error can be identified early and minimized. The least proportion of turnover is spent on first aid facilities and safety promotion. Perhaps this may reflect the belief that if accidents are prevented in the first instance, there would be no need for first aid facilities and that with the right training provided there is little need for safety promotion which will then just be provided to supplement the training.

6.5 BENEFITS OF ACCIDENT PREVENTION

The benefits comprise of both direct and indirect benefits to contractors. From the literature review (see chapter 3), it was revealed that contractors need to be convinced of the business benefits for investing in health and safety management and also assurance that there is a pay back in financial terms, as well as employee satisfaction. From this, it can be concluded that awareness of the financial benefits of accident prevention is necessary to the extent that it will encourage some decision makers to develop more efficient and practical health and safety management in their companies. To this end, this research elicited information on benefits of accident prevention through questionnaire survey (see section C of questionnaire in Appendix C). The full details of the results for direct and indirect benefits in proportion to turnover are presented in Appendix E (Tables 2 & 3) and are summarised in Tables 6.13 and 6.14. Here also because of the large standard deviations the medians are used as measures of central tendency.

6.5.1 Direct Benefits of Accident Prevention

The full results showing the direct benefits of accident prevention are presented in Appendix E Table 2. From the table 2 in Appendix E, it can be seen from the large standard deviations that the data is widely dispersed. Therefore, the median values are used as the measure of central tendency. Table 6.13 summaries the median values of the turnover to direct benefit ratios by size of companies for each of the eight direct benefit variables.

Table 6.13 Direct Benefits of Accident Prevention Ratio

Contractor	$T/Y_{insurance}$	$T/Y_{productivity}$	$T/Y_{compensation}$	$T/Y_{medical}$	T/Y_{damage}	$T/Y_{litigation}$	$T/Y_{investigation}$	$T/Y_{training}$	$T/Y_{totaldibenefit}$
Small	454.59	454.59	454.59	454.59	5000.00	5000.00	5000.00	454.59	57
Medium	800.00	504.00	315.00	600.01	3273.02	3273.02	1454.68	600.01	55
Large	3333.39	2100.04	800.00	3333.39	3333.39	3333.39	3333.39	3333.39	190
Total	1454.68	504.00	800.00	800.00	5000.00	2100.04	3273.05	1454.68	114.34

From Table 6.13, it can be seen that across the sample, out of every £114.34 turnover, £1.00 (0.87%) represents a total direct benefit of accident prevention. Comparatively, £1.00 out of every £57.00 turnover (1.75%) represents the total direct benefits gained by small contractors, whilst medium and large contractors gain a total direct benefit of £1.00 out of every £55.00 (1.82%) and £190.00 (0.53%) turnover, respectively. It can be inferred from these results that small and medium contractors gain relatively greater direct benefits in proportion to their turnover than large contractors. This finding is consistent with their relative expenditures on accident prevention. Interestingly, looking closely at the individual direct benefit variables, it can be observed that whereas small and medium contractors gain relatively greater direct benefits in proportion to their turnover than large contractors for the variables savings in insurance premium, productivity improvement, compensation claims, medical expenses and safety training, the converse is true for damaged materials, litigation costs and accident investigation where medium and large contractors derive greater benefits than small contractors. Perhaps it may be indicative of the fact that the costs associated with these variables in the event of an accident are similar regardless of the size of contractors and, therefore, represents a smaller proportion of turnover for medium and large contractors than small contractors.

It can also be inferred from Table 6.13 that overall (and even within the three categories of contractors) the greatest direct benefits are in the three areas of productivity improvement (504.00 or 0.2%), compensation claim savings (800.00 or 0.13%) and savings on medical expenses (800.00 or 0.13%). This suggests that although very often the emphasis is on insurance premiums (Ferret and Hughes, 2007) it appears that overall, the greatest savings are rather on productivity improvement, and compensation claims savings and savings on medical expenses. Interestingly, the direct benefit profiles across the three categories of contractors are fairly similar implying that this finding is applicable regardless of size.

What is further evident from Table 6.13 is that savings on damaged materials contribute the least to overall direct benefits. The median turnover to savings on damaged materials ratio is 5000.00 implying 0.02% of turnover. This is not surprising and may be indicative of the fact that not all accidents result in damaged materials, meaning that there is less scope for savings in relation to damaged materials when accidents are prevented.

6.5.2 Indirect Benefits of Accident Prevention

The full results showing the indirect benefits of accident prevention are presented in Appendix E Table 3. From the Table 3 in Appendix E, it can be seen from the large standard deviations that the data is widely dispersed. Therefore, the median values are used as the measure of central tendency. Table 6.14 summaries the median values of the turnover to indirect benefit ratios by size of companies for each of the six indirect benefit variables.

Table 6.14 Indirect Benefits of Accident Prevention Ratio

Contractor	T/Y_{image}	$T/Y_{workingman}$	T/Y_{sick}	$T/Y_{losttime}$	$T/Y_{cleaning}$	T/Y_{hiring}	T/Y_{indben}
Small	454.59	1454.68	454.59	454.59	5000.00	5000.00	833.33
Medium	266.67	600.01	1454.68	2100.04	3273.02	3273.02	643.00
Large	504.00	3333.39	3333.39	3333.39	11455.59	3333.39	939.00
Total	500.00	1454.68	1454.68	3333.39	5000.00	3333.39	833.33

From Table 6.14, it can be seen that across the sample, out of every £833.00 turnover, £1.00 (0.12%) represents a total indirect benefit of accident prevention. Comparatively, £1.00 out of every £833.00 turnover (0.12%) represents the total indirect benefits gained by small contractors, whilst medium and large contractors gain a total indirect benefit of £1.00 out of every £643.00 (0.15 %%) and £939.00 (0.11%) turnover, respectively. It can be inferred from these results that medium contractors gain relatively greater indirect benefits in proportion to their turnover than small and large contractors. This finding is consistent with their relative expenditure on accident prevention.

It can also be inferred from Table 6.14 that overall (and even within the three categories of contractors) the greatest indirect benefit is in the area of company image improvement (£500.00 or 0.2%). Following this, the two areas that benefit the most are working days saved (£1454.00 or 0.10%) and savings on sick pay (£1454.00 or 0.10%). This finding confirms the suggestion in HSE (2005) and Ferret and Hughes (2007) that improvement in company image is very often the greatest indirect benefit a company can gain from accident prevention. Beyond that, however, there are more benefits also to be gained from working day saved and savings on sick pay. Similar to the direct benefits, the indirect benefit profiles across the three categories of contractors are fairly similar implying that regardless of size, similar indirect benefits would be gained across the various measures.

What is further evident from Table 6.14 is that savings on cleaning/waste disposal contribute the least to overall indirect benefits. The median turnover to savings on cleaning/waste disposal ratio is 5000.00 implying 0.02% of turnover. This is not surprising and may be indicative of the fact that not all accidents result in cleaning/waste disposal, meaning that there is less scope for savings in relation to cleaning/waste disposal when accidents are prevented.

6.5.3 Comparison of Direct and Indirect Benefits, and the Total Benefits of Accident Prevention

The full results showing the comparative benefits of accident prevention are presented in Appendix E Table 4. From the Table 4 in Appendix E, it can be seen from the large standard deviations that the data is widely dispersed. Therefore, the median values are used as the measure of central tendency. These median values are summarised in Table 6.15. From Table 6.15 direct and indirect benefits and the total benefits of accident prevention are compared across different categories of contractors. From the median values shown in Table 6.15, it can be seen that across the sample, for every £78.13 of turnover, £1.00 (1.28%) is gained in total as the benefit of accident prevention. Comparatively, small contractors gain £1.00 out of every £53.00 (1.89%), medium contractors gain £1.00 out of every £47.00 turnover (2.13%), whilst large contractors gain £1.00 out of every £134.00 turnover (0.75%). It can be inferred from these results that medium and small contractors gain relatively higher proportions of their turnover in total as benefits of accident prevention than large contractors.

Table 6.15: Comparison of Direct and Indirect Benefits, and the Total Benefits of Accident Prevention

Contractor	$T/Y_{total\ direct\ benefit}$	$T/Y_{total\ indirect\ benefit}$	$T/Y_{total\ benefit}$
Small	57	833.33	53
Medium	55	643.00	47
Large	190	939.00	134
Total	114.34	833.33	78.13

According to the literature (refer to chapter 2) there is widespread belief that large contractors will gain more on accident prevention than medium and small contractors because of their ability to hire health and safety experts and, secondly, because of their better method of implementing health and safety (Lancaster *et al.* 2003). The results as discussed above, however, appear to contradict this belief. Indeed this finding rejects the null hypothesis, which stated that large contractors enjoy greater benefits from accident prevention than small and medium contractors. Therefore, the alternative hypothesis is accepted. There is enough evidence to support the alternative hypothesis that small and medium gained more benefits in proportion to their turnover than large contractors. Although in terms of the actual benefits, large contractors gain more than medium or small contractors, clearly small and medium contractors are benefiting more (as a proportion of their turnover) from accident prevention than large contractors.

It can be also inferred from Table 6.15 that the total direct benefits (114.34 or 0.87%) are greater than indirect benefits (833.33 or 0.12%). This finding also reject the null hypothesis (Ho), which stated that indirect benefits will be greater than the direct benefits associated with accident prevention. Therefore, the alternative hypothesis (Ha) is accepted. There is enough evidence to reject the null hypothesis. What this clearly shows is that the benefits, which arise from accident prevention, will be more likely to be direct than indirect and, therefore, more likely to be felt directly by contractors who are mainly aware of these direct benefits. This is not, however, to imply that indirect benefits are insignificant. As shown above, they represent 0.12% of turnover. For any contractor 0.12% of turnover represents significant revenue, and therefore, even though these indirect benefits are not always obvious, they are significant across the different categories of contractors and must not be overlooked, but rather highlighted more.

6.6 COMPARISON OF TOTAL COSTS AND TOTAL BENEFITS OF ACCIDENT PREVENTION

From Table 6.16 the total costs and the total benefits are compared across different categories of contractors taking turnover into account using BCR. The BCR was defined in chapter 3 section 3.3 as the ratio of the present value of the benefits relative to the present value of the costs (Preez, 2004) more formally:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} = B/C$$

BCR = Benefit cost ratio.

To facilitate the comparison between total costs and benefits in line with (Preez, 2004) for criteria decision making process, benefits to cost ratios are calculated as follows:

$$\frac{T/Y_{\text{totalcost}}}{T/Y_{\text{totalbenefit}}} = \frac{Y_{\text{totalbenefit}}}{Y_{\text{totalcost}}} = \frac{B}{C}$$

Where: B = Total benefits

C = Total costs

T = Turnover

Table 6.16: Comparison of Total Costs and Total Benefits of Accident Prevention

Contractor	$T/Y_{Total\ cost}$	$T/Y_{total\ benefit}$	C/B	B/C (%)
Small	143.87	53.00	2.71	36.9
Medium	170.22	47.00	3.62	27.6
Large	241.96	134.00	1.61	62.11
Total	205.97	78.13	2.64	37.9

From the values shown in Table 6.15, it can be seen that total benefits of accident prevention outweigh cost of accident prevention by a ratio of approximately 3:1 (62% benefit gain to 38% benefit loss). This means that it benefits contractors three times (62%) more financially to prevent accidents. In other words for every £1 spent on accident prevention £3 is gained as benefit. This finding provides support for null hypothesis which stated that the benefits of accident prevention will outweigh the costs of accident prevention. The alternative hypothesis claimed that the costs will outweigh the benefits is rejected. There is enough evidence from the statistic to accept the null hypothesis that benefits of accident prevention out weigh the costs.

This insight into the costs and benefits of accident prevention sets out the business case for accident prevention and provides an opportunity for contractors to take these into account when making decisions on health and safety measures. Clearly, expenditure on accident prevention will lead to higher financial benefits for contractors in the construction industry. Therefore, from the viewpoint of benefits and costs; it can be argued that it is more efficient to spend more on accident prevention than to let accident occur.

The ratio analysis in Table 6.16 also reveals two significant facts. First, that large contractor has the lowest benefits compare with their costs (1.6:1) than small and medium contractors. Alternatively, their costs are 62% of their benefits. Second, that medium contractor has the highest benefits relative to their costs (3.6:1). Alternatively, their costs are 27.6% of their benefits. Small contractors are fairly similar to medium contractors in terms of their benefit-cost ratio (2.7:1). These results are not surprising as small contractors, for instance, may not have experienced an accident in a year (Lancaster *et al*. 2003), whereas large contractors with more than 250 employees and annual turnover greater than £26m (DTI, 2005) would have a greater likelihood of accident occurrence in any particular year. What is surprising, however, is that given that majority of small and medium contractors manage their in-house training and use external consultants to assist them in meeting their health and safety requirements, while large contractors adopt internal policy on health and safety management; and, have an in-house specialist that can provide training on health and safety (see chapter 2 section 2.6.7), it would have been expected that large contractors would perform their health and safety tasks better and also have a better method of improving health and safety performance than the medium and small contractors. The findings contradict this expectation.

6.7 ANALYSIS OF QUALITATIVE PHASE

As stated in chapter 5 section 5.2, the interview was used in the qualitative phase, which was also meant to validate the framework. By conducting these interviews, it was possible to consider the relevance identified from the literature and also identify potential aspects of costs of prevention problems, which mirror the implementation of health and safety measures. The interviews were, therefore, an opportunity to test the relevance and comprehensiveness of these dimensions and the conceptual framework as a whole (see for instance Nicolini, 2002).

Key findings are summarised below.

The interviews conducted had revealed that most respondents felt the conceptual framework provided a true reflection of the costs and benefits of accident prevention. Most health and safety recognized the value of costing accidents prevention. However, few others regarded it as a non-value due to established commitment to health and safety at all levels within their business. Most of the respondents acknowledged that costs of accident ultimately impact on the financial performance of their organization.

As part of the data collection, it was deemed necessary to establish from the health and safety practitioners "*what aspect of health and safety measures was considered most important to their organization?*"

In response to this question, most of the respondents acknowledged safety training, PPE and safety personnel they considered most important and that they invested more money on these measures than other health and safety measures mentioned. One respondent highlighted that

"T*he cost of safety training is significant for us more than others mentioned*"

It was considered that the training of employees is the most important aspect of accident prevention. Training ensures awareness of potential hazards and the procedure for protecting the workers in the construction industry. According to Haslam *et al.* (2005); HSE (2006) training provides more directive instruction as to how an act should be performed. This means that training is crucial to the reduction of accidents on construction sites. It was emphasised that it provides workers with new skills and developing better career prospects. In line with the literature review, safety personnel was also considered as an important aspect of costs of accident prevention contractors should comply with and was noted as one of the largest investment on safety for contractors. This may be possible due to the requirement under the Construction Design and Management (CDM) Regulations 1994 (refer chapter 2). However, this was considered additional costs to contractors that were not normally included in the project costs. Nevertheless, in line with Tang *et al*. (2004) safety personnel are important in implementing health and safety policy as they monitor safety related matters in the construction industry. While the provision of PPE is thought to be the most significant element in terms of costs of accident prevention and reduction of accidents on construction sites (Lindqvist and Lindholm, 2001).

In response to the question, "Drawing from your experiences on construction sites, do you think more investment on health and safety measures can lead to more benefits to contractors as stated in the developed framework?" Most of the interviewees answered "yes". However, one contractor has reservation. According to him, "*The costs of safety investment are not really cost to contractors"*

As noted in chapter 2, safety investments are the proactive measures taken to minimize health and safety failures or accidents under different regulations in the HSWA 1974. It can be argued that they are costs to contractor, which though are not normally included in the project costs (cf. Hinze, 1990).

In response to question” Do you feel that the information provided in the framework is useful?” Most of the interviewees answered “yes” and some thought it was just to comply with the HSE regulations. Another respondent indicated the task of measuring the cost and benefit of accident prevention may be more even problematic given the difficulties associated with identifying the cost of prevention to benefit. This may be due to lack of information to identify the appropriate cost and benefit of accident prevention.

Other respondents considered cost of accident prevention to be important and beneficial cost to their business. However, they stress that it is often a balance needs to be weighed to present a business case. Another respondent highlighted that there are more benefits associated with preventing of accidents such as staff morale, reducing fatality, reducing stress, job satisfaction than financial gains.

“Benefits can be measured in terms of financial costs but I think it is more in terms of social benefits”

The research acknowledge that there exist social costs of accident and social benefits of accident prevention but the scope of the research is only limited to costs and benefits of accident prevention that are only measureable in monetary terms.

In response to question “Which aspects do you think are the most useful?” Most of the respondents acknowledge benefits are thought to be useful because it provides them information of the likely benefits from investing on safety measures. Another respondent recognizes that cost and benefit can be used as a means of justifying health and safety improvement in the construction industry.

"*If there are figures to prove how much it's costing to prevent accidents and how much benefit can be gained from such investment, it makes much easier to spend more on preventive measures".*

Another respondent think they realize what the cost of accidents are to their organization but don't realize the benefits behind preventing accident costs. One of the respondents explained that they were more concerned with cost of complying with health and safety regulations rather than costs implications of accidents. This implies that some of the respondents did not recognize the potential benefits of accident prevention which can be used as an incentive to justify investments on preventive measures. They thought potential legal implications and concern for the image and reputation of their organization are the most important.

In response to question "Which do you feel contains the most useful information that has not been mentioned already that you would find useful"

Few suggested that cost of "investigation", and "insurance" should be included as part of safety measure. The costs of accident investigation and insurance premium were, however, not included as part of costs of accident prevention because they are direct costs of accident, which arise from accidents occurrence. The purpose of insurance is to ensure that employers are covered for any legal liability to pay damages to employees who suffer bodily injury and/or disease during the course of employment (Aston, 1998). This is considered as part of overhead cost which can increase or decrease depending on health and safety performance. On the other hand, the cost of investigation is a procedure for employer or contractor in the aftermath of accident in adequately investigating the immediate and underlying causes of accidents to ensure that remedial actions are taken, lessons are learnt and long-term objectives are introduced (cf. Hinze *et al.* 1997). Therefore, they can not be part of proactive measures that are primarily undertaken by contractors to prevent accidents on sites.

In response to question "In general, do you think it is useful to provide companies with information about the costs and benefits of accident prevention to motivate them to improve health and safety in the construction industry?" Most of the respondents thought it was useful to provide them information. Another respondent responded that if potential benefits can be demonstrated from investing in health and safety measures, it could be an instrument in improving health and safety performance.

"If there are guidance tools to show there is a benefit by investing in health and safety measures, then health and safety performance might improve".

In order to provide confidence to section B2 of the quantitative main question which states "What would you estimate as the total cost incurred by your organisation after all accidents in the last 12 months on cost related to accident insurance premium?"

Respondents were of the opinion that higher premium will be paid up claim resulting from inaction of contractor on health and safety was determined by the insurer, while lesser premium will apply if accident happened as a result of non-compliance on the part of the worker or sub-contractor. Third scenario: No additional premium will be paid if no direct cost resulting from insurance claim, i.e. the new premium will be significantly lower than the current one.

The cost of an insurance premium is largely based on statistics, not necessarily on individual habits or history. For example, construction workers may have more serious on-the-job accidents than an administrative staff in the same organisation. Conversely, an insurance premium may be reduced if there is improvement in health and safety.

This means that an accident claim can dramatically change the insurance premium rate, especially if the contractor is at fault. Rates can go up or remain stable.

It can be seen from the above discussions that the findings from the interviews suggest that generally, the relationships highlighted by the conceptual framework are well founded. The framework can thus be used as the basis of the quantitative questionnaire survey, which formed the 2nd phase of the research data collection – the main component of the research investigation. The conceptual framework was modified slightly in accordance with the few minor modifications suggested by the interviewees. Having established this, the research was able to proceed to the quantitative phase.

6.8 DISCUSSION OF RESULTS

The contractors captured in the survey have business activity in many sectors of the construction industry and can be categorised on the basis of size and turnover into small, medium and large contractors. This distinction is critical because according to Lancaster *et al.* (2003) size has an effect on the measures to prevent accidents and consequently is related to the costs of accident prevention, with large contractors believed to incur the greatest costs and small contractors the least costs. Indeed, it was found from the data that size is related to the cost of accidents with large contractors having the greatest cost of accidents and small contractors having the least cost of accidents. This finding further reinforced the notion that different categories of contractors incur different costs of accident prevention as indicated above. This notion, which was encapsulated in hypothesis, was, however, not borne out by results of the ratio analysis of turnover to costs of accident prevention. Although in terms of actual expenditure large contractors spend more than small or medium contractors (with small contractors spending the least), the ratio analysis shows that actually, in proportion to their turnover, small contractors are spending more on accident prevention than medium and large contractors (with the large contractors spending the least). This finding is interesting because it provides a basis for challenging commonly held views that small contractors are not doing enough by way of accident prevention. If the general consensus is that small contractors need to do more, then it is important for the industry and policy makers (e.g. HSC) to consider the possibility of providing the additional financial support required for small contractors to improve their health and safety measures as the findings of this research seem to suggest that a greater proportion of their turnover (relative to medium and large contractors) is already going to accident prevention.

The analysis on accident prevention costs further revealed that the greatest emphasis in terms of spending was on safety training and safety personnel salaries. This finding is also interesting as it appears to suggest that the human element is the most significant component of accident prevention and, therefore, requires the most resources to address through training and proper supervision or monitoring of risks and hazards. Implied in these results is a tacit recognition that if knowledge, awareness and monitoring are improved, there will be less need for spending on measures like first aid facilities, which are required after the fact, with safety promotion just provided as a supplement to the training.

With regards to the benefits of accident prevention, the ratio analysis revealed that there are both significant direct and indirect benefits. Although it was hypothesised that large contractors would enjoy greater benefits than medium and small contractors as a result of their greater spending on accident prevention, the opposite was found to be true from the ratio analysis with small and medium contractors benefiting more (in proportion to their turnover) than large contractors. Though surprising, this result is nevertheless consistent with the corresponding expenditure levels on accident prevention as already recounted in the preceding paragraphs. When direct benefits are compared with indirect benefits to test hypothesis H_0 and Ha, it can be seen that contrary to the hypothesis direct benefits are greater than indirect benefits indicating that any benefits, which arise from accident prevention, are more likely to be felt directly by contractors than indirectly. This, therefore, makes a compelling case for encouraging contractors to take necessary preventive measures as these would lead to benefits that they are readily aware of.

When the total costs of prevention are compared with the total benefits of prevention in response to the main research question and hypothesis, it can clearly be seen that the benefits of accident prevention far outweigh the costs of accident prevention by a ratio approximately 3:1. The average ratio of preventive costs to benefits of 3:1 found in the research gives a conservative rule of thumb to use in estimating accident preventive costs. For a number of reasons this figure is probably an underestimation of what would be obtained from a more extensive study of both moral and economic benefits difficult to measure variables such as saving in death, job satisfaction or employee morale that were not included. This finding is of critical importance to this research as it clearly sets out the business case for accident prevention. It demonstrates unequivocally that there is a net benefit arising from accident prevention and, by so doing, provides justification for a more proactive approach to accident prevention. As indicated in chapter 1, there is a strong moral case for accident prevention. Clearly, on the basis of these results, there is also an equally strong business case for accident prevention.

6.9 SUMMARY

This chapter has presented the first part of the data analysis and made it possible to specify the kinds of construction organisations to which the inferences drawn from this research were applicable, and the contexts within which they operate. The chapter further presents qualitative and ratio analysis of the data on costs and benefits of accident prevention and an overview of the trends within the sample. Further evaluation to identify differences in the costs and benefits of accidents prevention across different categories of contractors is also presented. The evidence from the analyses clearly indicates that costs and benefits of accident prevention across contractors within the sample, and by inference across the UK construction industry, vary on the basis of size of contractors. It is shown from the results that small and medium contractors spend more than large contractors, and derived greater benefits as well**.** It is further shown that direct benefits are greater than indirect benefits and that total benefits far outweigh the costs of accident prevention. Having established this business case for accident prevention the next chapter explores the nature of the relationship between the costs of accident prevention and the benefits of accident prevention to establish whether or not the benefits can be predicted by examining the costs of accident prevention.

CHAPTER 7

DEVELOPMENT OF AN ACCIDENT PREVENTION CBA MODEL

7.1 INTRODUCTION

To gain further insights into costs and benefits of accident prevention, this chapter addresses the fifth objective of the research which is to analyse the data statistically with a view to developing a cost-benefit regression model of accident prevention. By so doing, this chapter attempts to answer the final research question of whether greater expenditure on accident prevention would improve safety performance on construction sites, and yield greater benefits to contractors. This research question, which led to the hypothesis (see chapter 4), is explored by application of two statistical techniques: correlation and regression analysis, to the field data to develop the substantive model relating costs of accident prevention to the benefits accruing from such costs. It concludes with discussions of the findings and the implications for health and safety management in the UK construction industry.

7.2 APPLICATION OF TWO STATISTICAL TECHNIQUES: CORRELATION AND REGRESSION

The analyses in this chapter are undertaken using two main statistical techniques; correlation and regression analysis as discussed in chapter 5 section 5.8.3 and 5.8.4.

7.2.1 Correlation

As discussed in chapter 5 section 5.8.3, test of correlation was carried out to assess the existence of relationship between the costs of accident prevention and benefits of accident prevention. Non-parametric was used in chapter 6 because the data was converted to ratio of turnover in order to compare the costs and benefits of accident prevention. Pearson correlation coefficient was used here to assess the relationship between the raw costs and benefits of accident prevention data. Pearson correlation coefficient is the most useful statistics (Frees, 1996). Pearson's correction was used to measure the strength of the relationship between cost of accident prevention and benefit of accident prevention. Pearson's correlation coefficient requires only data that are interval or ratio level for it to be an accurate measure of the linear relationship between two variables (Field, 2005). Because the field data collected is at the ratio level, it implies that this technique can be reliably applied to this research to estimate the strength of the relationship between the costs and benefits of accident prevention. Moreover, as argued by Field (2005), this technique is a useful precursor to regression modelling as it provides, prior to developing a full model, a fair idea of how closely a change in one variable is tied to a change in another variable and vice versa and also whether multicollinearity exists among the predictors. Multicollinearity is the situation where predictors are highly correlated with each other (i.e. $r > 0.9$) and is a source of concern in regression (Blaikie, 2003; Brace *et al.* 2003 & Field, 2005). Otherwise it can be therefore concluded that there is no collinearity within the data (Field, 2005). In this research, multicollinearity is not a source of concern as there is only one predictor variable.

The correlation matrix produced in this analysis is shown in Table 7.1. The significant level is 0.001 (2-tailed). The full correlation matrixes of each cost of accident prevention to the total benefits is shown in Appendix G

Table 7.1 Correlation Analysis Matrix

		Totalbenefits	Totalpreventivecosts
Totalbenefits	Pearson Correlation	1.000	.687**
	Sig. (2-tailed)		.000
	N	78.000	78
Totalpreventivecosts	Pearson Correlation	.687**	1.000
	Sig. (2-tailed)	.000	
	N	78	79.000

**. Correlation is significant at the 0.01 level (2-tailed).

Where

Totalpreventivecosts = Total costs of accident prevention

Totalbenefits = Total benefits of accident prevention

The Pearson's correlation (r) (refer Table 7.1) reveals a positive, strong and highly significant association between the total benefits of accident prevention and the total costs of accident prevention ($r = .687$; $P < 0.001$). This means that as the costs of accident prevention increase, there is a corresponding increment in the level of benefits accruing from accident prevention. This finding, thus, provides further evidence in support of assertions made in chapter 6 that companies that spend more on accident prevention also derive greater benefits. Therefore, the null hypothesis is supported. There is a positive relationship between cost of accident prevention and benefit of accident prevention -i.e. the higher the cost of accident prevention, the higher the benefit of prevention. The alternative hypothesis which states that there is a negative relationship between cost of accident prevention and benefit of accident prevention -i.e. the higher the benefit of accident prevention, the lower the costs accident prevention is rejected. There is insufficient evidence to support this claim. It can be concluded from this result that there is sufficient evidence of a linear relationship between costs and benefits of accident prevention to proceed with the regression modelling.

7.2.2 Regression

Correlations can be a very useful research tool but they tell us nothing about the predictive power of variables (Field, 2005). Regression addresses this weakness. Whilst correlation is concerned with measuring the strength of the relationship between variables, regression analysis deals with the nature of the relationship between those variables (Fleming & Nellis, 1994). Regression seeks to predict an outcome variable from either a single predictor variable or from several predictors. In this research, simple linear regression is adopted as the research seeks to examine the influence of costs of accident prevention (independent variable) on benefits of accident prevention (dependent variable). Various regression techniques exist, ranging from simple linear regression through multiple regression which are the most commonly applied, to more complex regression techniques such as polynomial, logistic, exponential, sine and cosine curves, and growth and decay curves. The choice of which technique to apply, often depends on the type and number of variables involved, and the technique which yields the best prediction.

In the case of this research (which seeks to assess the nature of the relationship between two variables), simple linear regression represents the most appropriate starting point as this technique examines the strength of linear association between one independent variable and one dependent variable, which has to be either scale or ratio data. The word simple means there is a single independent variable (Ryan, 1997). It helps to explain the change in quantitative terms that a variable has on a dependent variable. The procedure is accomplished by expressing in the form of an equation (see chapter 5 section 5.8.4), the relationship between the dependent variable (benefits) and the independent variable (costs).

7.2.2.1 Statistics Produced in Linear Regression

In regression, a number of statistics are produced to help interpret the results. R represents a measure of the correlation between the observed value and the predicted value of the criterion variable. The R-square (R^2) is a statistic that indicates on a scale of zero to one how variations in a dependent variable are accounted for by particular independent variable such that zero indicates no influence and one indicates 100 percent. R^2 is a measure of how good a prediction of the outcome can be made by knowing the predictor variables (Field, 2000; 2005). However, R^2 tends to somewhat over-estimate the success of the model when applied to the real world, so an adjusted R^2 value is calculated which takes into account the number of variables in the models and the number of observations (i.e. participants) the model is based on (Brace *et al.* 2003). Thus, the adjusted R^2 is useful because its gives an indication of how much of the variance in the outcome is accounted for in the population from which the sample is chosen.

As part of the analysis, an analysis of variance (ANOVA) is carried out. The ANOVA tests whether or not the model is a useful predictor of the outcome variable (Field, 2005). The output for the ANOVA analysis of regression model displays information about the variation that is not accounted for by the model. A model with a large regression sum of squares in comparison to the residual sum of squares indicates that the model accounts for more of the variation in the dependent variable. Very high residual sum of squares on the other hand indicates that the model fails to explain a lot of the variation in the dependent variables and other variables that are not in the model could be accounting for some of the variation of the dependent variable. The ratio of these variances is known as F-ratio. F-ratio is used to assess how well a regression model can predict an outcome compared to the error within that model (Field, 2005). The F-ratio is the test statistics for the ANOVA. A t-test is produced to see whether each β differs significantly. Each of these beta values has an associated standard error which is used to determine whether or not the *beta*-value differs significantly from zero (Field, 2005).

7.2.2.2 Assumptions of Linear Regression

There are many ways assumptions associated with the linear regression can be checked. Assumption of linear relationship of two variables can be checked by looking at the scatter plot of the data (Norusis, 2003). Scatter plot is the basic graphical tool used to investigate the relationship between two variables (Frees, 1996). The point should cluster around a straight line. Alternatively, it can be checked by plotting residuals against the values of the independent variable and against the values of the predicted variable. In this case the point should be randomly scattered in a band around 0. A non random pattern means an additional variable in the regression (Norusis, 2003).

Hair *et al.* (1998) as cited in Ankra (2007) indicated that the principal measure of prediction errors is the residual, which is the difference between the observed and predicted values for the outcome variable. Analysis of the residuals is, thus, the principal means of identifying violations of the assumptions. According to Hair *et al.* (*ibid*), plots of the standardised residuals versus predictor and outcome variables is the basic method of identifying assumption violations. Another method is the use of the normal probability plot (P-P plot) which compares the standardised residuals with a normal distribution, which is represented by a straight diagonal line. If the distribution is normal, then the residual line must closely follow this diagonal line (Hair *et al.*, 1998). However, Ryan (1997) argues that linear does not mean that the relationship between the two variables can be displayed graphically on a straight line. It means that the model is linear in the parameters.

The Durbin-Watson test for serial correlation of the residuals (SPSS, 2004) can also be used to check the assumption of normality (Norusis, 2003; Field, 2005). Durbin statistic informs whether the assumption of independent errors is tenable: less than 1 or greater than 3 raises alarm (Field, 2000). The closer to 2 the value is the better. It means that assumption has certainly been met. Another direct way of checking normality is to create a dot plot or histogram of the standardized residuals (Frees, 1996). The histogram of standardized residuals should not be lopsided but rather be bell-shaped, or at least symmetric. As indicated in Field (2005), it is only when all these assumptions are met that the model can be accurately applied to the population. All the assumptions were thus, tested as regression model was generated.

These assumptions must be met for the regression analysis to guarantee a model in which the actual errors in prediction are as a result of the real absence of a relationship among the variables and not caused by some characteristic of the data not accommodated by the regression procedure (Hair *et al.* 1998). If there is evidence that the assumptions necessary for regression are violated the data can be transformed (Norusis, 2003). This means that the scale on which the variables are measured can be changed. For example, take logarithms, squares or square roots of either dependent or independent variables. If the dependent variable is transformed, its distribution is changed. Violation of assumption can lead to results that are difficult to interpret and apply (Norusis, 2003).

7.3 DEVELOPMENT OF A COST BENEFIT MODEL

A model is a mathematical abstraction that is an analogy of events in the real world (Motulsky, 1995). It is written as an equation that defines a value that will predict (Y) from one or more variables (X). In this research, the sixth objective was to develop a CBA model to reflect the real world experiences of contractors in relation to accident prevention costs and the benefits accruing from such costs.

7.3.1 Dependent Variable (Total Benefits of Accident Prevention)

The benefits as stated in Chapter 2 and 4 are derived from the data obtained from completed questionnaire directed at the health and safety managers in the UK construction industry. These benefits stated in Chapter 2 section 2.8 and 4 section 4.4 comprise of savings on the followings: insurance premium; productivity improvement; compensation claims; medical expenses, lost time of other employees, accident investigation, litigation costs, working day lost, hiring of tools and equipment, sick pay, safety training, company image improvement were all added together to get the total benefits of accident prevention.

7.3.2 Independent Variable (Total Costs of Accident Prevention)

As mentioned in Chapter 2 section 2.7 and 4 section 4.3, costs of accident prevention comprises of first aid facility, PPE, safety promotion, safety training, safety personnel officer's salary were all added together to get the total costs of accident prevention.

7.3.3 Regression Modelling

Simple linear regression was applied to the data with the total costs of accident prevention to contractors included as the predictor variable and total benefits of accident prevention as the outcome variable. The results of the simple linear regression analysis are presented in Table 7.2. Table 7.2 shows that 47% (R^2 =0.47) of the proportion of variations in the benefits of accident prevention is explained by the variable costs of accident prevention. R^2 is a measure of how good a prediction of the benefits of accident prevention can be made by knowing the predictor variable (Field, 2005). The R^2 adjusted is 0.465 implying that the model explains 47% of the variations in the benefits of accident prevention within the population leaving 53% unexplained.

Table 7.2 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.687[a]	.472	.465	9.82890	.472	67.990	1	76	.000	1.653

a. Predictors: (Constant), Totalpreventivecost

b. Dependent Variable: Totalbenefit

The expenditure on accident prevention, thus, fails to explain all the possible variation in the benefits of accident prevention. Some plausible explanations for this result include the fact that there are also market forces at play, which directly and indirectly affect the magnitude of monetary benefits that organisations derive from accident prevention. For instance, savings in insurance premiums may, potentially, be due to the fact that organisations are free to switch insurance companies when they are more likely to obtain more competitive offers. Similarly, contractors can save on litigation costs just by changing solicitors. These factors are dictated by the market and because some of these market factors were not considered in this research, it is not surprising that the linear model fails to explain all the variance in the outcome variable.

Moreover, the relationship between costs of accident prevention and benefits of accident prevention may not necessarily be entirely linear and, therefore, it may be necessary to explore other regression techniques to see if the amount of variance explained increases. What is very clear from the statistics in Table 7.2 is that accident prevention measures, and the costs associated with implementing these measures, can be relied on as a basis for predicting the magnitude of financial benefits from accident prevention. The relationship between these two variables is captured in Table 7.3.

Table 7.3 Coefficient Analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	10.142	3.030		3.347	.001	4.107	16.178
	Totalpreventivecost	2.001	.243	.687	8.246	.000	1.518	2.484

a. Dependent Variable: Totalbenefit

From Table 7.3, the model signifying the influence of costs of accident prevention on benefits of accident prevention to contractors could be expressed as:

Total Benefits of Prevention = 10.142 + 2.001 Total Costs of Prevention

The above equation shows the unique monetary contribution that the costs of accident prevention make to the benefits of accident prevention. The unstandardized coefficient provides the relative measure of extra benefits from accident prevention. The results reveal that costs of accident prevention contribute extra benefits (unstandardized coefficient = 2.001, t = 8.246 and P < 0.005). In the model, the costs of accident prevention (t = 8.246, P < 0.005), is a predictor of benefits of accident prevention and clearly makes a significant contribution to this model. That the t – statistic is greater than 2 (rule of thumb) is a confirmation of the reliability of this estimate.

A t-test is used to see whether each β differs significantly. Each of these beta values has an associated standard error which is used to determine whether or not the *beta*-value differs significantly from zero. The *t*-test associated with a *b*-value is significant (sig. <0.005) the predictor is making significant contribution to the model. The smaller the significance value the greater the contribution of the predictor (Field, 2005). From the magnitude of the *t* –statistics, the costs of accident prevention has a great economic impact on benefits of accident prevention. The model has a high statistical significance level indicated by a P-value of less than 0.005 for the F-statistics (Table 7.4). This indicates further that the independent variable accounts well for the variations in benefits of accident prevention. The positive coefficient ($\beta_1=2.001$) confirms the positive relationship between costs of accident prevention and the benefits accruing thereof. This result implies that any expenditure on accident prevention will produce more benefits for contractors. This finding provides support for null hypothesis, which stated that the more contractors spend on accident prevention the greater the benefits they will derive. It can, therefore, be inferred from this result that greater expenditure on accident prevention would improve health and safety performance on construction sites.

Table 7.4 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6568.309	1	6568.309	67.990	.000[a]
	Residual	7342.152	76	96.607		
	Total	13910.462	77			

a. Predictors: (Constant), Totalpreventivecost

b. Dependent Variable: Totalbenefit

Table 7.4 reports the ANOVA for the regression. The ANOVA which tests whether or not the model is a useful predictor of benefits of accident prevention gives a significant result of ($F = 67.99$, $P < 0.005$) indicating that this model significantly improves the prediction of benefits of accident prevention. The large residual sum of squares in comparison to regression sum of squares confirms that the model fails to explain a lot of the variation in the dependent variable and other variables that are not in the model could be accounting for some of the variation of the dependent variable.

7.3.4 Testing the Assumptions of Regression

To test for the independence of the error terms, the Durbin-Watson statistic was produced. This gave a value of 1.653, which is less than 2 (greater than 1) as shown in Table 7.2, indicating that this assumption has not been violated. An analysis of residuals was undertaken. The histogram shows a bell-shaped distribution indicating that the assumption of normality has not been violated.

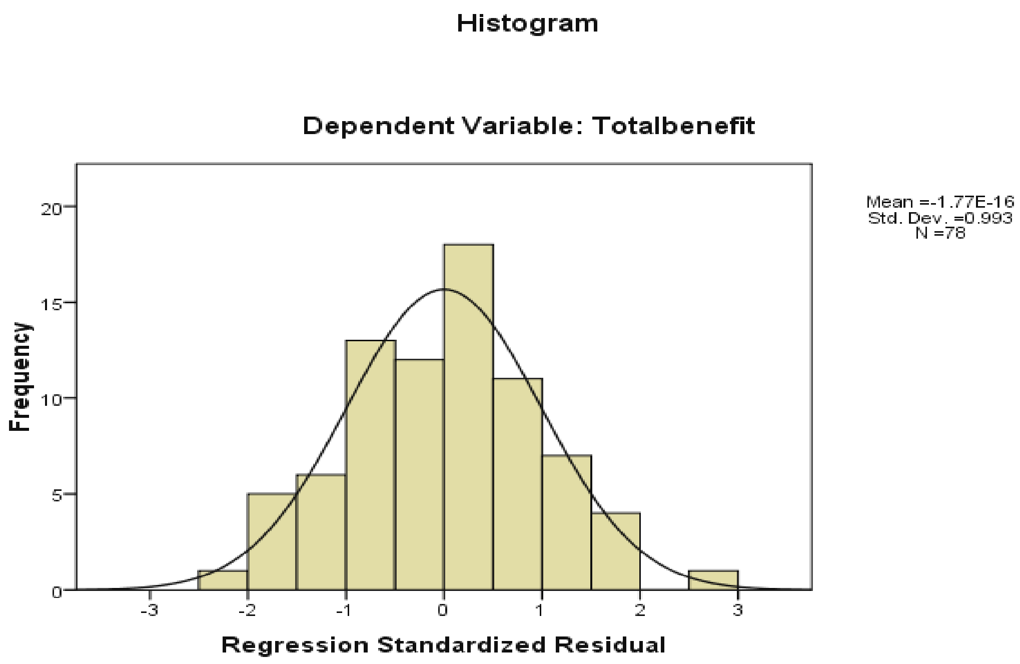

Figure 7.1: Histogram for frequency against regression standardized residual

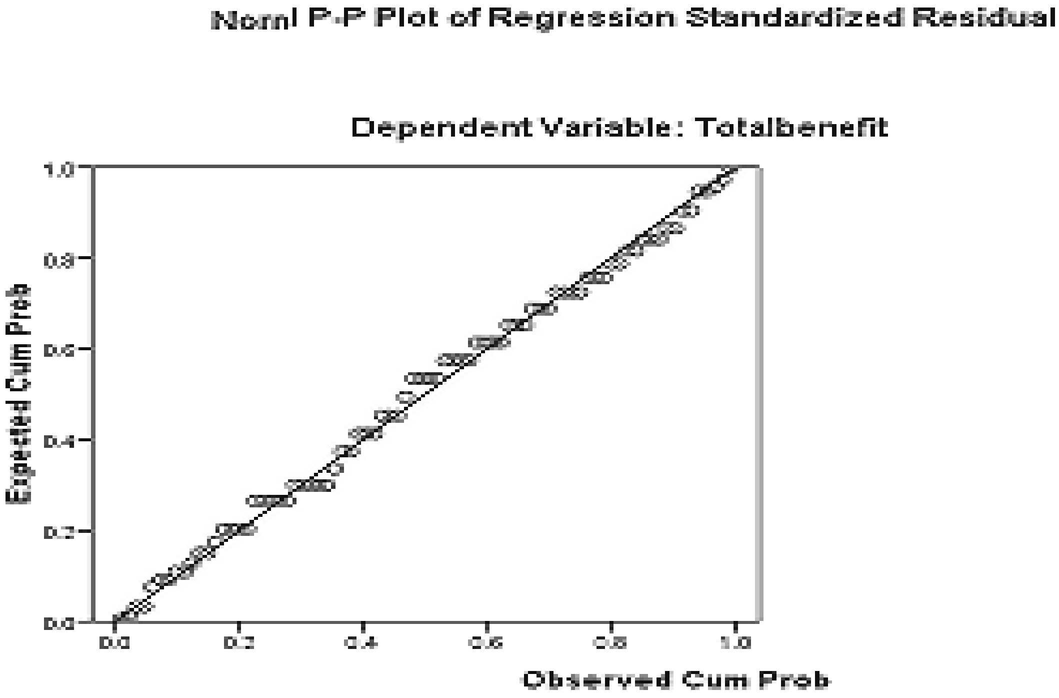

Figure 7.2: Normal probability plot of regression standardised residual

The normal probability plot of expected cumulative probability against observed cumulative probability Fig.7.2 also shows points generally lying close to the straight line indicating that the residuals are approximately normally distributed thus confirming the conclusions drawn from histogram.

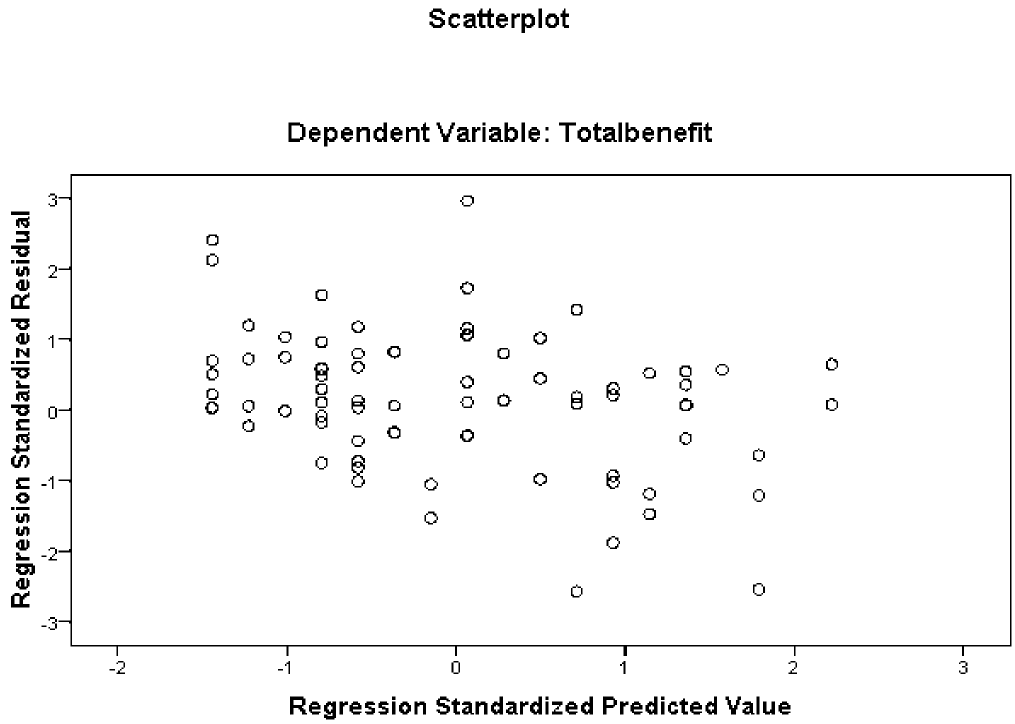

Figure 7.3: Scatter of standardized residual against unstandardized predicted value

Linearity of the relationship between variables was assessed by examining Figure 7.3. The random distribution of data points indicates that there is no evidence of a non-linear relationship and therefore this assumption has also not been violated. This result provides reasonable compelling evidence that the substantive model developed is valid. Taken together, these findings indicate that the regression model produced is an accurate and valid representation of the data and can be applied to the population.

7.4 DISCUSSION OF THE RESULTS AND THE IMPLICATIONS FOR HEALTH AND SAFETY MANAGEMENT

It was found from the correlation analysis that costs of accident prevention are positively and significantly related to benefits of accident prevention. The result of the regression shows that benefits of accident prevention are positively influenced by costs of accident prevention. This finding further reinforced the notion that costs of accident prevention are related to benefits of accident prevention as indicated above. This notion which was encapsulated in the hypothesis, which stated that the more contractors spend on accident prevention the greater the benefits they will derive is, however, supported by the results of the correlation and regression analysis of costs of accident prevention to benefits of accident prevention. The regression analysis shows that the more contractors spend on accident prevention the greater benefits they derived.

These results imply that further expenditure on costs of accident prevention will produce greater benefits of accident prevention. They also imply that an additional cost of accident prevention is associated with extra benefits of accident prevention. It was revealed from the literature in chapter 2 that expenditure on costs of accident prevention contributes to strong construction health and safety management. Because of poor record of health and safety in the industry (Egan, 1998 and Bomel, 2001) improving health and safety on construction sites can be identified with benefits of accident prevention. The calls for improvement in construction health and safety (Egan, 1998 and Bomel, 2001) are, therefore, justified. The contractor has a legal responsibility to provide a safe and secure workplace, provide competent co-workers, adequate materials and equipment as well as safe system of works with proper training and supervision (HSE, 2005).

As stated in chapter 2, accidents could be caused by lack of management commitment it is the responsibility of the employer to provide a safe working environment. Take for instance, injury may leave employee unable to continue working and it is probably then inevitable that employment may be terminated. Compensation claim can be made for loss of earnings and loss of future income as a result of accidents. Legal action can be taken against if nothing is done to prevent accidents occurrence. The employer is required by law to take steps to prevent any reasonably foreseeable accidents or injuries (see chapter 2 section 2.6).

This study also clarified the benefits of accident prevention. These results suggest that the benefits of accident prevention can contribute to a decline in accident occurrence in the construction industry. The study has several strengths. However, this study also has several limitations. Non-accidents costs were not considered in the study. There are many benefits of implementing health and safety management that can not be easily evaluated in terms of money. These benefits are easy to overlook due to the difficulties of quantifying them in economic terms. The CBA model simply presents financial information that can be used to drive decision making.

Given the importance of health and safety to the performance of construction industry, this finding suggests the need to adopt benefit approach to improve health and safety in construction industry. This will provide the desirable benefit to raise contractor’s confidence in compliance with safety measures. These preventative costs are primary undertaking by contractors to improve health and safety management in the construction industry to benefit worker, employer and society.

Accidents in construction industry have a direct effect on cost (Ferret and Hughes, 2007). The obvious benefits to contractors are the prevention of accidents and reduction of costs of accidents that will translate to lower construction costs and higher profit margins for contractors. Besides the obvious reason to improve health and safety management, because human life is precious, fewer workplace injuries and fatalities also help reduce costs of accidents. This finding is interesting because it provides a basis for challenging commonly held views that health and safety is not an investment by way of accident prevention. This, therefore, makes a compelling case for encouraging contractors to spend more on costs of accident prevention as this would lead to greater benefits of accident prevention. This finding is also of critical importance to this research as it clearly sets out the business case for accident prevention. It demonstrates unequivocally that there is a greater benefit arising from accident prevention and, by so doing, provides justification for a more proactive approach to accident prevention. Clearly on the basis of these results, there is strong business case for accident prevention.

7.5 SUMMARY

This chapter is devoted exclusively to the development of the substantive model relating costs of accident prevention and the benefits accruing from such costs. Pearson's correlation coefficients, regression analyses, analysis of variance (ANOVA), are employed in the development of the model. It is abundantly clear from the above results that there is a relationship between costs and benefits, which is supported by the empirical evidence. The results of the regressions analysis show that the benefit considered is both positively influenced by costs of accident prevention. In evaluating the costs of accident prevention, there was recourse to employ ANOVA for determining whether the variance in the quantitative variables differed significantly than expected by chance. Similarly, regression analysis was employed to evaluate the unique contribution of accident prevention to benefits of accident prevention. These analyses were aided by the use of quantitative data analysis computer programme, SPSS and Microsoft excel. Having developed the CBA model of accident prevention the next chapter describes the validation process, which includes both external and internal validation.

CHAPTER 8

VALIDATION OF THE PREDICTIVE MODEL

8.1 INTRODUCTION

This chapter presents the results of the validation of the cost benefit analysis model of accident prevention developed for the construction industry in the UK, as stated in the final objective of the research. The aim of the validation process is to help establish whether the concepts and methodologies used in developing the model are sound and also to establish whether the findings are reliable. Validation also provides a firm background against which, the findings could be generalised. Thus, validation is important because it reflects the potential objectivity and reliability of the model. A generic discussion of the concept of validation is first presented. Thereafter, a methodology for undertaking the validation exercise namely, external and internal validation procedures are introduced. Subsequently, the details involved in both validation procedures, as applied in this context, are discussed.

8.2 THE CONCEPT OF VALIDATION

The concept of validation has different meanings in the various stages of the research process especially the conceptual, methodological and empirical domain (Brinberg and McGrath, 1992). At the conceptual domain, the validation can be established by assessing the effectiveness, internal consistency, testability and adaptability of the concepts used. At the methodological domain, it would be expected that efficiency, power (rigour), unbiasness, and explicitness would prevail. Alternatively, at the substantive domain, it would be expected that the research should be beneficial or relevant in terms of any potential practical applications and should also be subject to replication and convergence towards identifying its boundaries.

In principle, any attempt at validating a research process should reasonably aim at integrating the three domains and a plausible methodology for assessment is for the researcher to strive towards value, correspondence (or fit) and robustness (Brinberg and McGrath, 1992). Value, in this sense, deals with the worthiness of the research, while correspondence is the degree at which the features of the relations in the various domains match or fit together. Robustness deals with testing the consistency of the empirical findings through replication, convergence and differentials (Walliman, 2001). That is, robustness deals with the wider issue of generalizability or as is often called external validity (Brinberg and McGrath, 1985; Bailey, 1987 and Blaikie, 2003).

It is interesting to note that while researchers agree that both internal and external validation are important for validating the research process, the literature is largely silent on what form the internal validation process should take (see for instance Fellows *et al.* 2002). A useful technique that has been employed successfully in recent times to achieve this integration is the two dimensional methodology identified as; external and internal validation (see for instance, Proverbs, 1998; Xiao, 2002; Ahadzie, 2007; Ankra, 2007 and Egbu, 2007). External validation is particularly used in respect of the substantive domain of the research process, while internal validation has been applied to the conceptual and methodological domains.

8.3 VALIDATION OF MODEL

Model validation is the process of confirming that the proposed model is appropriate, especially in light of the purposes of the investigation (Frees, 1996). Validation of a model is the process of assessing the ability of the model to do what it sets out to achieve (Egbu, 2007). This process tries to ensure that the model represents the characteristics of the general population and not peculiar to the samples used in its estimation (Hair *et al.* 1998). The two components of validation (internal and external) are examined below.

8.4 INTERNAL VALIDATION

In Rosenthal and Rosnow (1991), internal validity has been defined as the degree of validity of statements made about whether *X* causes *Y* – the primary concern being to rule out plausible rival hypotheses. Similar definitions are provided in Fellows and Liu (1997), and Garson (2007). Internal validation seeks to outline the strength of the model as well as assess the literature search (Egbu, 2007). The key areas to examine in assessing the strength of the model; are the value of R, R^2 and adjusted R^2.

In the test model to assess the costs of accident prevention to contractors in UK construction industry, the model summary for model (benefits of accident prevention) R=0.687 (.69%), R^2= 0.472 (47%) and R^2 adjusted = 0.465 (47%) demonstrates a credible model for assessing the effect of economic costs of accident prevention on benefits of accident prevention. They also provide evidence of the appropriateness of data used in the analysis. In addition, the model is significant in all important aspects, F values, and Durbin Watson statistics. Accordingly, the significantly low P-value of less than 0.05 for the t-test for the individual partial regression coefficient reported in Table 7.3 as well as the F-test reported in Tables 7.4 confirm that, statistically, the result of the regression is significant and could not have been obtained simply by chance. This shows that the results are reliable enough to form the basis for generalising the conclusions to the relevant population.

8.4.1 Convergence of Research Findings and Academic Validation

The process of disseminating the findings of this research to practitioners and the wider academic community through the publication of conference proceedings involved a review and assessment of the validity of the research and its findings by independent referees. As noted in Xiao (2002) review in this manner provides an opportunity for the methodologies, meanings and interpretation of the research to be questioned. It is a process of critical inquiry, which is meant in theory to provide an informed, fair, reasonable and professional opinion about the merits of research work (Runeson and Loosemore, 1999). Fenn (1997) has observed that review is used as the gold-standard throughout academia in the UK. Feedback from such a process serves to enrich research work and potentially improves its findings (Alkass *et al.* 1998). During this review process, the article is sent anonymously to two – four independent experts in areas related to the particular subject of the paper (Xiao, 2002). The essence of anonymity is to ensure that possible biases or prejudice in the review are eliminated, although in reality this is not always achieved (Runeson and Loosemore, 1999). There are four possible outcomes of this review. These are (i) acceptance without change; (ii) acceptance subject to minor changes; (iii) acceptance with major amendments; or (iv) rejection (Runeson and Loosemore, 1999). In all cases, the referees provide feedback outlining the basis of their decision, often raising issues which range from trivial to fundamental.

During the course of this research, five (5) conference papers were developed and published and two presentations were made at both American Real Estate Society, USA and University of Wolverhampton Built Environment and Engineering Research, UK where it was subjected to expert interrogation and modification to improve its rigor and reliability. These papers also were presented at the annual international conferences of the Association of Researchers in Construction Management (ARCOM) (2006 and 2008), the Construction Management and Economics 25th Anniversary Conference (2007) the Association for the Advancement of Cost Engineering (AACE) 51st Annual Conference Nashville, Tennessee, USA (2007) and Sustainable Built and Natural Environment Conference, Obafemi Awolowo University, Nigeria (2007). In addition, two journal papers have been developed and submitted to the International Journal of Project Management and Construction Management respectively, which are currently under review. With the challenge and feedback from the academic community during presentation and review, which have been incorporated in the research and into this thesis, the research has been improved significantly making the findings more robust and reliable as argued by Xiao (2002). Thus, it can be argued that there is convergence between the research finds and academic validation.

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This technique has also successfully been used by many other researchers, such as Proverbs (1998); Xiao (2003); Ankrah (2007); Ahadzie (2007). It is argued that the acceptance of these papers for publication demonstrates the convergence of published research and academic validation. These conference papers can be found in

- 22nd Annual ARCOM Conference Birmingham. 4-6/09/06 Vol. 1 page 295-304
- Towards A Sustainable Built and Natural Environment. Obafemi Awolowo University Ile- Ife Nigeria Page 126-132
- Association for the Advancement of Cost Engineering (AACE), 51st Annual Conference, Nashville, Tennessee. USA (2007)
- Construction Management & Economics 25th Anniversary conference at the University of Reading, UK (2007) Vol. 1 page 65
- Annual ARCOM Conference Cardiff. 1-3/09/08 Vol. 1 page1035-1043.
- International Journal of Project Management *(*Under review see Appendix I).
- International Journal of Construction Management *(*Under review *see* Appendix J).

These conference papers were reviewed by independent referees with outcomes such as acceptance with minor changes. The changes were made and the papers were published in the various conference proceedings as listed above. Thus, it can be argued that there is convergence between the research findings and academic validation.

8.4.2. Convergence: Literature Search, Questionnaire Development and Analysis

Validation of the questionnaire development is reflected in the convergence with the literature search and the theoretical framework adopted (see chapter 4). Thus, the predictor variable had reasonably theoretical bases for it to be included in the questionnaire. Three sets of analyses were undertaken in respect of the data elicited, namely; the correlation analysis, the one-sample t-test, and regression analysis. Convergence of the findings from the literature and these analyses were identified. That is, the findings from all three analyses were found to replicate the literature. The details are as follows:

8.4.3 Convergence of Literature

Convergence of findings from the literature and the output of the model have been identified. This presupposes that the influencing factors identified by the model from the analysis of the survey data in the UK construction industry are replicated in the literature. The core conclusion in the literature on health and safety was that costs of accident prevention affect the benefits of accident prevention. The significant point to note about the literature search, however, is the absence of similar studies, which try to analyse quantitatively the effects of costs of accident prevention on benefits of accident prevention in the UK construction industry.

8.5 EXTERNAL VALIDATION

According to Brinberg and McGrath (1985), the essence of external validation is to gain confidence in the findings and what they mean. It is about ensuring the robustness of the research and about assessing its generalisability (Reason and Rowan, 1981; Rosenthal and Rosnow, 1991; Fellows and Liu, 1997). The process of external validation tries to assess the ability to generalise the applicability and transferability of the model unto other situations with similar characteristics (Egbu, 2007). Various external validation techniques are discussed including the choice made for the purpose of this study.

8.5.1 Background to the External Validation Analysis

Five main techniques have been identified for undertaking external validation (Snee, 1977; Good and Hardin, 2003; Field, 2005). These are:

1) Using independent verification obtained by waiting until the future arrives or through the use of surrogate variables;

2) Splitting the samples and using one part for estimating the model and the other for validation;

3) Re-sampling, taking repeated samples from the original sample and refilling the model each time;

4) Using Stein's equation of re-calculating the adjusted coefficient of determination (R^2) (Field, 2005);

5) Approaching experts to comment on relevant aspects of the model (Brinberg and McGrath, 1985).

As a result of resource constraints (in particular financial and time limits), using independent verification when the future arrives was an option that could not be pursued here. The re-sampling procedure was also discounted because, as noted by Field (2005), researchers, particularly in social science related research, such as this rarely have sufficient data to perform this kind of analysis. While splitting the sample seems to be the easier option, it also sometimes suffers from the same problem as re-sampling if the data is not large enough (Good and Hardin, 2003; Field, 2005). However, Brown (1975) had suggested that instead of splitting one can adopt what is termed "pool aside". The proposition is to set some of the data aside for validation purposes in which the mean square errors (i.e. the residuals or predictive fit) can be used for validation. If this methodology is adopted then Picard and Berk (1990) implies that errors can be minimised by using approximately 1/4 (one quarter) of the sample set aside for developing the model for the validation.

Alternatively, Stein's equation re-calculates the adjusted R^2 and so can be used for validation (Field, 2005). According to Field (2005), the equation used in calculating the adjusted R^2 in SPSS is somewhat flawed because it does not account for how the regression model would predict an entirely different set of data. Stein's equation addresses this flaw and, thus, reflects how well the model will predict an entirely different set of data (Stevens, 1992; Field, 2005). That is, Steins equation is a measure of how well the model can predict scores of different samples from the same population. Stein's equation can also be used to confirm if the model has the potential of predicting quite well difference samples of data from the population.

Given that in this study, the data collected was not very large, it was decided to approach some "experts" especially those who completed the main questions (i.e. health and safety managers/safety personnel officers) to comment on the potential relevance of the model as suggested by Brinberg and McGrath (1985). It is argued in Brinberg and McGrath (1985) that it is this process of validation that transforms research information into knowledge.

In order to fulfil this requirement, quantitative strategy was employed in this research involving the use of quantitative data. The relationships identified through the quantitative analysis were presented to experienced practitioners to provide their views on the extent to which such relationships between costs and benefits actually exist in the construction industry, based on their own experience of working in construction industry. With this approach, described in Silverman (1993) as respondent validation, it is argued that where participants verify the tentative results of the research, this generates more confidence in the validity of the findings. The procedure adopted from Silverman (1993) involved providing participants with a research report (see Table 8.1) and recording their response to it. It has been argued that this process of going back to participants with tentative results and refining them in the light of participants' reactions is a characteristic of good research (Reason and Rowan, 1981). This approach has been used extensively in construction management research with Hari *et al.* (2005), for instance, interviewing five experts to validate their research findings.

8.5.2 Selection of the Experts and Response

For the model to be of acceptable standard, it is important that the validation generates useful and relevant comments from relevant experts. This can only be achieved if the experts chosen to participate in the validation have the required expertise. In view of this, the experts were selected from the list of practitioners who responded to the postal questionnaire survey. The use of the previous survey's respondents list as a sample frame has two main advantages. Firstly, these were individual health and safety managers in construction and consulting firms with relevant expertise and experience in health and safety. Secondly, their prior involvement in the earlier survey makes them familiar with this research, which will ensure a good response rate. Prior to sending out the questionnaire, letters were sent to the experts requesting their kind assistance in the validation exercise. Following this, a brief description of the model incorporating a worked example was sent out via post to 35 selected experts. The mail also included the validation questionnaire and a covering letter, stating the purpose of the research, the validation process and what was expected of them.

8.5.3 Analysis of Experts' Response

Out of 35 experts who were sent questionnaires for the validation, only 12 responded. The majority of them were in favour of the model indicating that the model is a positive contribution to the subject of health and safety in construction industry. The respondents were asked in a structured, semi-closed questionnaire to comment on the model. In addition to offering ticked-box responses, some of the experts provided their own comments about the model. All the responses received were, to a large extent, positive (see an example in appendix H). A summary of the responses to the various questions in the questionnaire are set out in Table 8.1

Table 8.1 Summary of response from experts

Validation Criteria	Expert Response											
	1	2	3	4	5	6	7	8	9	10	11	12
Costs of accident prevention influence benefits of accident prevention	Yes, highly valid	Yes, valid	Yes, valid	Yes, but not valid	Yes, but not valid	Yes, valid	Yes, valid	Yes, highly valid	Yes, highly valid	Yes, but not valid	Yes, highly valid	Yes, highly valid
CBA approach demonstrate that the costs of accident prevention can be offset by benefits accruing from accident prevention	Yes, highly valid	Yes, highly valid	Yes, valid	No, not valid	Yes, valid	Yes, highly valid	Yes, highly valid	Yes, highly valid	Yes, but not valid	Yes, valid	Yes, valid	Yes, highly valid
Benefits of accident prevention far outweigh the costs of accident	Yes, highly valid	Yes, highly valid	Yes, valid	Yes, highly valid	Yes, valid	Yes, but not valid	Yes Valid	Not valid	Not sure of its validility	Yes valid	Not valid	Yes, highly valid
Greater expenditure on accident prevention improves safety performance	Yes, highly valid	Yes, highly valid	Yes, but not valid	Yes, valid	Yes, highly valid	Yes, valid	Yes, highly valid	Yes, highly valid	Yes, valid	Yes, valid	Yes, valid	Yes, but not valid
Model address an important problem on cost of accident prevention	yes, significant	yes, significan t	yes, quite significan t	but not significan t	no, would make no difference	yes, quite significan t	yes, significant	yes, significan t	not sure of its significan ce	yes, significa nt	yes, quite significan t	no, would make no difference
Model capable of assisting contractors on decision making	Yes, highly capable	Yes, capable	Yes, capable	Yes, capable	No, not capable	Yes, capable	Not sure of its capability	Yes, capable	Yes, capable	No, not capable	Yes, capable	Not sure of its capability
Model is simple, clear and easy to understand	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Description of the model	comprehen sive	Adequate	Adequate	Adequate	comprehen sive	Adequate	Adequate	Poor	Adequate	Poor	Adequate	Adequate

In response to whether from their own experiences of working in the construction industry they found health and safety measures influence health and safety performance on construction sites most of the respondents confirmed that is highly valid. To quote a respondent, "*Health and safety measures are likely to influence health and safety site performance but insurance is likely to be the most important factor".*

In response, also, to the question of whether from their experiences of working in construction industry they found CBA approach can help to demonstrate that the costs of accident prevention can be offset by benefits accruing from accident prevention the respondents confirmed this to be highly valid. To quote a respondent to this finding *"Yes, I am in support of this point"* Another respondent, made the comment that "*Given the wide spread use of CBA and the important of H&S, it is very surprising that no body has brought the two together before. It is, therefore, potentially very important piece of work*"

There was a mixed response to the question of whether from their experiences of working in the construction industry, benefits of accident prevention outweigh the costs of accident prevention. The perception of the respondents were different, most of them indicated that the benefits outweigh the costs, while others suggested that benefit is important in terms of health and safety but sometimes the cost might be dependent on the situation or scenario of the event. One respondent viewed health and safety from an insurance perspective. Another respondent added that *"This is what we experience"* One respondent, however, challenged this particular finding stating that it was "*hard to believe that costs and benefits of accident prevention could be quantified".*

In response, to the question of whether from their experiences they found that greater expenditure on accident prevention improves health and safety performance on construction sites, one respondent, found this outcome not surprising stating that: *"I find that health and safety does make a difference in construction industry".* Another respondent added that *"Benefits of accident prevention in construction industry can improve health and safety performance".* Whilst for some this outcome was not surprising, one particular respondent disagreed outright with this finding arguing that *"One would have expected that benefits of accident prevention would flourish in construction industry where there is a safer working environment."* In trying to rationalise this finding, another respondent who felt that the findings were possibly valid suggested that *"Absolutely true –contractors need to make profits and at the same time prevent accidents on sites."*

As can be observed from Table 8.1, most of the experts agreed that the model addresses costs and benefits of accident prevention. Concerning its capability in performing its intended function accurately, most of the experts were of the opinion that it is capable. This suggests that the model would be regarded by practitioners as a very useful tool for decision making. In terms of the model's completeness, most experts felt that the model is comprehensive and detailed, touching on all costs of accident prevention and relevant financial benefits of accident prevention. With regard to comprehensibility, most experts found the model to be clear and simple to understand and implement. One expert noted "*it has covered an aspect of accident prevention in a simple and logical manne.*"

It can be concluded, from the above responses, that although generally, the respondents are affirming the findings of the questionnaire survey, the limitations of questionnaire surveys have also been made evident in the scepticism of some of the respondents in respect of some of the findings. It is possible that the scepticism was as a result of some of these limitations. This not withstanding, the opinions of the experts were in favour of the model suggesting that the model would be regarded as valuable tool for decision making. This represents a positive contribution to the body of knowledge within construction organisations. It can be concluded that from these results that, generally, the findings of the main survey are accurate reflection of the situation within the construction industry, and to that extent, generalisations can be made for construction industry across the UK.

8.6 SUMMARY

This chapter reports on the validation of the CBA model. The Chapter describes the validation process, which includes both external and internal validation. The internal validation sought convergence of the research findings, published research and academic validation. Five (5) papers have been developed and published in various conference proceedings. In all these papers, a significant number of references have been cited to support the arguments advanced in these papers. It is, thus, argued that this research is convergent with the established knowledge. Experienced practitioners were invited to share their opinions on the findings. Their views are reported within this chapter. Generally, the results from the main analysis implying that the findings reported are valid and can be generalised across construction industry in the UK. Moreover, when respondents were invited to share their opinions on these findings, they generally concurred with the findings even though in a few specific instances they expressed scepticism. Even where there was scepticism, this was not unanimous and, therefore, does not invalidate the findings. In the next chapter, the conclusions of this research based on the analyses and validation efforts will be set out. The recommendations will also be put forward.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

This Chapter presents the conclusions and recommendations drawn from the entire study. Here the objectives and research questions of the research are reassessed and highlighted. Major conclusions drawn from the research and future areas of research are also presented. In this chapter, the research is brought to a close by summarising the issues addressed throughout the study. This is then followed by a recapitulation of the key research questions. Thereafter, a summary of how the key objectives were satisfied is elucidated followed by the main conclusions of the research. The thesis is brought to a close with recommendations for future research and future adoption of the findings in practice.

9.2 CONCLUSIONS OF THE RESEARCH

The main questionnaire consisted of 37 (thirty seven) questions that focussed on information about costs of accident prevention, direct and indirect costs of accidents and benefits of accident prevention. The results indicated that the primary elements that contributed to cost of accidents prevention are safety personnel salary and training. A summary of the questionnaire results is shown in Appendix E & F. The companies that participated in the questionnaire were large (>250), medium (>50<250) and small (<50) in terms of their construction contract size.

In terms of “costs of accident of prevention” the appropriate expenditure on these costs should provide a firm foundation towards improving their health and safety performance and, indeed, construction performance. This suggests that to help improve construction health and safety performance, contractors should spend more on costs of accident prevention. The finding revealed that large contractors have the greatest costs of accidents, while small contractors have the least. From the ratio analysis, it shows that in proportion to their turnover, small contractors spent more on accidents prevention than medium and large contractors, with large contractors spending the least. This finding provides a basis for challenging commonly held views that small contractors are not doing enough by way of accident prevention. The ratio analysis further revealed that when total costs of accident prevention was compared to the total benefits of accident prevention, the benefits far outweigh the costs of accident prevention by a ratio of about 3:1, which means that when contractor irrespective of their sizes spend £1.00 on accident prevention, they gain £3.00. This clearly set out a business case for accident prevention. It further demonstrates that there is net benefit arising from accident prevention.

It was also revealed that reasonable correlations exist amongst the total costs and total benefits of accident prevention ($r = 0.687$, $P < 0.001$), which means that benefits and costs of accident prevention is positively and significantly related. This also means that as the costs of accident prevention increase the benefits of accident prevention increase. The result of the model indicates that any expenditure on costs of accident prevention will spring - up enormous benefits to contractors. This means that the more contractors spend on accident prevention the greater the benefits they derive. These are compelling evidence that improving health and safety measures would improve health and safety performance on construction sites. It can be concluded that the cost of accident prevention significantly influences the overall benefits of construction industry. This significant found provide empirical support for the main research question 1.

Thus, the implication of this finding is that while it might be important for contractors to have all the necessary costs of accident prevention relating to the management of health and safety issues, the costs identified are likely to enhance the achievement of higher performance of health and safety on construction sites. The analysis undertaken suggests that there is potential for contractors to improve on their health and safety performance as perceived by the respondents. It appears that on construction health and safety management, cost is the most important consideration. The findings suggested that the success criteria in health and safety performance could be listed as company image improvement, working day saved, saving in sick pay, saving in compensation claim, productivity improvement and saving in medical expenses.

While health and safety officers may be persuaded of the importance of reducing construction accidents, they are often limited in what they are able to do due to financial constraints. The management should be persuaded that an investment on health and safety measures is good for the company's profitability. This is equally true for large contractors that spent more and have little benefits compare to small and medium contractors available resources for health and safety investment. The primary reason for the success of small and medium for having greater benefit is that their management have made commitment to be safe. Without motivation from the management there is little chance that successful health and safety measures will develop. Small construction companies discovered that it is profitable to be safe. Loss of reputation, increased insurance costs, loss or potential litigation costs, working day loss, cost of sick pay, cost of compensation claim, productivity loss and cost of medical expenses are strong reasons to invest in health and safety.

The relevance of benefits of accidents prevention is that it will encourage decision makers in developing efficient and practical health and safety management in the construction industry. The model should assist contractors and designers in decision making regarding health and safety issues in the construction industry. The industry do not understand the financial loss to their organisation, managers will find it difficult to understand the financial benefits the safety measures provide. The result is that health and safety issues are not fully integrated, as a result, contractors view it in terms of compliance-oriented reactive strategy. In the light of this, contractors and designers can use these quantitative results to establish effective health and safety in achieving improved construction site safety performance

9.3 A CRITICAL REVIEW OF THE RESEARCH

This research has achieved its aim of providing a general overview of the cost of accident prevention in the UK construction industry and exposing some of the significant associations between the costs of accident prevention to contractors and benefits of accident prevention outcomes. In undertaking this study, a number of choices have been made, which have ultimately influenced the methodology adopted, data collected, analysis undertaken and, consequently, the findings. Whilst these choices have facilitated the achievement of the objectives of this research, they have also imposed some constraints on the research.

To address the objectives of this research, the choice was made to focus on the question relating to costs and benefits of accident prevention. By making this choice, the study was, as a result, limited to examination of the costs and benefits of accident prevention within the UK construction industry. Within the main quantitative phase of the study, data on costs and benefits of accident prevention were collected by means of a questionnaire survey of knowledgeable informants. The use of a single informant in each case is supported by the literature (cf. Ogbonna and Harris, 2000; Anderson, 2003). Through the developed model, which showed the positive and significant relationships between the costs of accident prevention and benefits that accrue from these costs, this research offers a tool to contractors to capture cost outlays on accident prevention and use that as a basis for predicting the potential benefits of accident prevention. These findings will help contractors and indeed different stakeholders in the industry to make appropriate decisions, take suitable measures, and devote the necessary resources required for accident prevention on construction projects.

From the above discussions, it can be seen that the research undertaken has addressed the objectives set out. It has also explored a range of techniques suitable for analysing costs of accident prevention and drawing inferences about the relationships between these costs and benefits, which can be applied in other similar studies. However, there is still some potential for improving such studies to provide deeper insight into costs and benefits of accident prevention within construction industry.

9.4 RECOMMENDATIONS FOR INDUSTRY

As noted throughout the thesis, effective health and safety management are helpful for improvement in construction site performance. The cost of accident prevention identified here offers contractors in the UK the opportunity to have a clearer idea of what accidents prevention cost to their organisation. The findings can, therefore, be used to assist contractors in their decision making in respect of accident prevention on construction projects. It also recommended that contractors seeking to improve health and safety could use the findings to make informed and objective decisions towards accidents prevention on construction sites.

Interestingly, while health and safety practice contributes to construction performance in the UK construction industry, it is also evident that appropriate expenditure for preventing accidents is still lacking. This finding could, therefore, be used as a foundation for developing an appropriate health and safety management. The study could be used to identify costs and benefits of accident prevention to the needs of contractors and also collectively used by a professional body such as the HSE. The most important task is to ensure that accidents in the industry are reduced to the barest minimum as recommended by the HSE. Within the limitations outlined in chapter 1, this research has provided some direction on what an effective health and safety measure ought to be, and some indication of aspects where there is potential for improvement in the industry. A number of recommendations can, thus, be put forward to provide some direction for improvement in this regard as follows:

- To improve construction health and safety management, and better overall performance of construction industry, it is recommended that contractors spend more on costs of accident prevention to ensure a safer working environment. In practical terms this means spend more on first aid facility, provision of PPE, safety promotion, safety training and safety personnel.

- To increase benefits of accident prevention, and better overall performance, it is recommended that practitioners devote more effort towards rigorous implementation of health and safety measures to make their working environment safer. In practical terms this means trying to foster a greater sense of identification with the workers, and putting more emphasis on elimination of accidents.
- To increase production without compromising the health and safety measures, perhaps, workers must be educated that health and safety issues are responsibility of every one. The workers must also be adequately trained to raise consciousness so that hazards and potential human error can be identified early and minimized.
- It is recommended that contractors use the CBA model to evaluate the cost of accident which will facilitate decision making in the management of construction health and safety. The use of CBA could undoubtedly improve the health and safety management on construction sites.
- It is recommended that the developed cost –benefit analytical tools can also be used by designers to enable them design projects that are safer, and estimators to enable them costs for appropriate health and safety measures to prevent accidents on sites. This can contribute to creating a working team to design out health and safety problems from the onset stages of the projects.

In summary, cost matters and as construction organisations strive for improved construction performance outcomes, it is recommended that contractors who are the beneficiaries of improvements in health and safety performance devote more attention and resources towards spending on health and safety measures. These issues should go to the heart of contractor's commitment to prevent accident towards achieving their objectives. Some of the practical mechanisms that can be employed in this regards are induction of new entrants, providing ongoing training, safety promotion, continuous monitoring, establishing appropriate reward structures that target accident prevention.

9.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the findings of the research and the limitations that have been noted, a number of recommendations are put forward to provide some direction for future research endeavour in this domain as follows:

- This research has revealed a significant association between costs and benefits of accident prevention that might be indicative of a cost effect of accidents. It is recommended that further research be undertaken to delve deeper into the costs of accident in undermining efforts to improve health and safety performance. Given that cost is an inevitable part of construction; such research will represent a significant contribution to knowledge.
- Within the scope of research, it was not possible to consider social costs such as death, pain and suffering of the affected worker and other costs or damage associated with human feelings. Future research could usefully be carried out in this important area. It is believed that these costs are significant losses to contractors, workers and society.
- The research can further be developed to explore social benefits of accident prevention such as savings in fatality, pain and suffering, job satisfaction, staff morale, stress so as to provide further evidence to guide contractors in their decision making on

health and safety measures. Benefits from such a research could be wide ranging. However, this will require further data collection to test and improve the rigour of the model.

- As indicated in section 1.8, the research context was limited to construction industry in the UK. It is entirely plausible that there may be significant differences in the findings if this study is replicated in other countries. It is therefore, recommended that this study is replicated in other countries to reduce the costs of accident.

9.6 RESEARCH QUESTIONS

In undertaking this research five main questions were posed, namely:

1. What impact do costs of accident prevention have on benefits of accident prevention to contractors?
2. Do the benefits of accident prevention outweigh the associated costs of accidents prevention in the construction industry?
3. Can the CBA approach help to demonstrate to stakeholders that the costs of accident prevention can be offset by the benefits accruing from accident prevention and help them make better health and safety policy decisions?;
4. What is the correlation between costs and benefits of accident prevention?
5. Will greater expenditure on accident prevention improve safety performance on construction sites, and yield greater benefits to contractors?

From question 1, it was proved that costs of accident prevention have impact on benefits of accident prevention to contractors. It is evident from the ANOVA Table 7.3, and the results of t-statistics show that cost of accident prevention influence benefits of accident prevention, which lead to health and safety performance.

The research questioned on whether the benefits of accident prevention outweigh the associated costs of accident prevention in the construction industry. As can be seen from the result of the ratio analysis (Table 6.16), the benefits of accident prevention outweigh the costs of accident prevention. The benefits of accident prevention are seen to outweigh the costs of accident prevention for a number of reasons. Health and safety systems have a clear impact on the number and severity of accidents. There can be no price put on the lost of human life and, therefore, any health and safety effort that protects its employees is valued. These results imply that benefits of accidents prevention accrued to contractors which include saving in compensation claims exceed the costs of accident prevention. For example, if there is adequate provision of PPE and workers are made to comply by enforcing their uses, the rate of accidents might decline and, therefore, reduce compensation claim. The costs of providing PPE is less than compensation claim when a company is prosecuted and fined after an accident had occurred e.g. death. It is considered that the benefits had outweigh the costs with benefits including raised awareness amongst staff, improved company image, decrease of time lost through accidents. Unless contractors see these benefits, they will continue to incur costs as the results of accidents.

Given the importance of health and safety to the performance of construction industry, this finding suggests the need to adopt benefit approach to improve health and safety performance in the UK construction industry. This will provide the desirable benefits to raise contractor’s confidence in compliance with safety measures. In answering question

3, evidence from the literature (see chapter3) has proved that the CBA approach can help demonstrate to stakeholders that the cost of accident prevention can be offset by the benefits accruing from accident prevention and help them make better health and safety policy decisions. This is supported by the analysis and both internal and external validation where experts on health and safety expressed their opinions on the developed model. In answering to question 4, on whether there is correlation between costs and benefits of accident prevention. It was established in the correlation analysis that there is positive correlation between costs and benefits of accident prevention. This implies that when the costs of accident prevention increase, the benefits also increase. In answering question 5, it was proved that greater expenditure on accident prevention improves safety performance on construction sites, and yield greater benefits to contractors. From the magnitude of the *t* –statistics and a high statistical significance level indicated by a P-value of less than 0.005 for the F-statistics, the results imply that any expenditure on costs of accident prevention will produce more benefits for contractors and improves safety performance on construction sites.

9.7 REVIEW OF OBJECTIVES

The main aim of this research, as noted earlier, was to develop a CBA model of accident prevention on construction projects by investigating the costs and benefits of accident prevention and to explore the relationship between these preventative costs and benefits, with a view to drawing attention to the economic consequences of effective/ineffective management of health and safety by contractors in the UK construction industry**.** The model should provide construction decision makers with valuable insight to compare costs and benefits of accident prevention to improve decision making in respect of health and safety issues/measures prior to commencement of site operations and during site operations. Subsequently, a number of research objectives were developed in order to collectively satisfy this aim. Here, the research objectives are revisited to highlight the extent to which they were accomplished through the various phases of the research.

Objective 1: Critically review literature on UK construction health and safety including statistics and legislation to contextualise the health and safety problems of the construction industry, and to establish from a theoretical perspective the cost and benefit of accident prevention elements that need to be considered when investigating accident prevention;

Some important issues regarding the significance of health and safety measures were identified from the health and safety literature including recent contributions in construction health and safety publications. While health and safety management were described as an important contributor to improving construction health and safety performance, which will lead to construction performance, it was established that this is yet to be adequately reflected in construction industry in the UK.

In particular, the literature revealed that while some attempts have been made towards reduction of accidents to improve health & safety in the UK construction industry, the focus of most of these studies have centred on causes and cost of accidents but overlooked the benefit side of accident prevention. The review was, therefore, helpful in underpinning the view that there was indeed a dearth of research towards costs and benefits of accident prevention in construction industry and, thus, provided reasonable justification for the need of the research.

Objective 2: Critically review the principles of cost benefit analysis (CBA) and to make a case for its applicability to the construction health and safety context;

This second objective was satisfied by undertaking an extensive review of CBA. To this effect, health and safety practices in the UK construction industry were also discussed with particular reference to the contribution of health and safety in construction. The literature revealed that, very little has been done to help engender the use of CBA in health and safety in the UK construction industry. While there existed an acknowledgement of the contribution made by health and safety in the construction industry, a lack of detailed research on CBA in the context of accident prevention was also revealed.

Objective 3: Develop a CBA conceptual framework of accident prevention that captures the benefits of accident prevention and contrasts these costs, to show the potential for achieving an overall benefit;

This third objective was, therefore, addressed by reviewing, in particular, the relevant literature on CBA and health and safety management. This led to the identification of the costs and benefits of accident prevention as an appropriate methodology for addressing this research agenda. This framework was adopted here as it offered the opportunity for a potentially more detailed conceptualisation of accident prevention

Objective 4: Collect relevant data from health and safety practitioners and professionals in the UK construction industry on costs and benefits of accident prevention to test the conceptual framework;

Bailey (1987) argues that the development of an appropriate conceptual model is key to identifying the relevant research methodology. The identification of an appropriate conceptual framework paved the way towards fulfilling this objective. Subsequently (and in particular), in order to help establish the necessary convergence with similar studies on health and safety, positivism was adopted as the underlying research paradigm that influenced the design of the research instrument. Therefore, using the construct from the framework and also drawing extensively on recent construction health and safety literature, a broad range of costs of accident prevention were identified. These costs represented the independent variable of the model and some potential benefits of accident prevention were identified to represent the dependent variable (see chapter 4). Based on these dependent and independent variables, a research instrument in the form of a self administered postal questionnaire was developed.

Objective 5: Employ appropriate statistical analyse with a view to explore the relationship between costs and benefits of accident prevention.

In fulfilling this objective, two statistical analyses (correlation and regression) were employed. From the correlation analysis, it was found that significant association exist between costs and benefits of accident prevention. Simple linear regression was chosen as against other alternative methods such as multiple regressions, discriminant analysis and artificial neural network because of, in particular, its explanatory characteristics, which was a most desired function of this research.

Objective 6: Develop a cost-benefit regression model that relates costs of accident prevention with benefits of accident prevention;

In fulfilling this objective, the developed model using statistical techniques including correlation and simple linear regression analysis as designated in chapter 7 produced significantly respectable R and R^2 values. The regression technique included maximizing the R squared value (i.e. the coefficient of determination), and including only variables that had been proven to be statistically significant through regression, ANOVA, the Durbin-Watson test and residual analysis.

Objective 7: Test, refine and validate the model towards its predictive accuracy and potential relevance for practical application of the regression model.

This objective was fulfilled by employing external and internal validation procedures. External validation involved the expert's opinion. It revealed that the predictive accuracy of the model was robust and, thus, could be generalised. As part of the external validation a consensus of expert opinion was also sought from the field incorporating experienced professionals and practitioners in the UK construction industry, to help gauge the potential relevance of the intended application of the model. Internal validation comprises of R, R^2 and R^2 adjusted demonstrated a credible model for assessing economic costs of accident prevention on benefits of accident prevention. Academic validation was established through publication of the research findings at major international conferences. The convergence of the three sources of information provides evidence of the validity of the findings.

9.8 SUMMARY

This chapter presents the conclusions and recommendations drawn from the entire study. Here the objectives and research questions of the research are reassessed and highlighted. This chapter has also provided a review of the original research objectives and the extent to which they were achieved. In summary, the research has developed a model representing a robust mechanism for predicting the benefits of accident prevention. The model could be used by construction decision makers especially contractors in their decision making in respect of health and safety issues to identify strengths and weaknesses. It is contended that the developed model has the potential for improving the health and safety performance in the UK construction industry. Major conclusions drawn from the research and future areas of research are also presented. The chapter concludes with recommendations for construction industry practitioners, and recommendations for future research.

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APPENDICES

Apendix A: Pilot Questionnaire

School of Engineering and the Built Environment

Wolverhampton, WV1 1SB
United Kingdom

Dear Sir/Madam,

A Pilot Survey on Development of a Cost Benefit Analysis (CBA) Model of Accident Prevention on Construction Project

I am currently undertaking a PhD research study on construction health and safety management at the School of Engineering and the Built Environment, University of Wolverhampton, under the guidance of Mr Keith Potts, Prof. David Proverbs and Dr David Oloke. Specifically, the research aims to develop a cost-benefit analysis model to help provide a decision support tool to assist contractors and designers improve decision making in respect of health and safety issues/policies

Your participation in this project is completely voluntary. It would be very much appreciated if you complete all parts of the questionnaire. Please note that any information you provide will be treated with the **strictest confidence**.

We do appreciate the questionnaire will take some of your valuable time. However, it will provide a tremendous contribution to the current study on measures to improve the overall performance of construction industry

On behalf of the University of Wolverhampton, I thank you for your time and contribution to this research. Any further information and the final outcome of the research will be available upon your request. I hope to share my results by publishing them in journals and presenting them at conferences in the UK and overseas. Please feel free to contact me if you require further information.

Please return completed questionnaire in the enclosed SAE or fax to:

Elias Ikpe
MA211B
School of Engineering and the Built Environment (SEBE)
University of Wolverhampton,
Wulfruna Street,
Wolverhampton.
WV1 1SB.
West Midlands. UK.

Tel: 07956879062: 01902323582:
Fax: 01902322743
E-mail: Elias.Ikpe@wlv.ac.uk

Section A: General information (Optional)

Name of respondent: (optional) ______________________________

Years of experience as health and safety practitioner: ______________________

Position in the organisation: ______________________________

Name of organisation: (optional) ______________________________

Business address: (optional) ______________________________

Tel:______________Fax:___________ E-mail:____________ (optional)

A2 What area of the construction sector does your organisation operate in? Please tick one box only

A) Civil engineering	☐	C) Consultancy	☐
B) Building construction	☐	D) General contractor	☐
E) Specialist subcontractor	☐	Other (please specify) --------------------------	

A3: Approximately how many employees are there in your organisation?

Full time	
Part time	

Section B: COSTS

B1: Please estimate how much your company spent on the following health and safety issues in the last 5 years (March 2002- March 2007)

	<£100	100-500	500 - 1000	1000-10000	10000-50000	>50000	Don't know
First-aid treatment	☐	☐	☐	☐	☐	☐	☐
Safety promotion	☐	☐	☐	☐	☐	☐	☐
Personal protective equipment	☐	☐	☐	☐	☐	☐	☐
Safety Training	☐	☐	☐	☐	☐	☐	☐
Safety Personnel	☐	☐	☐	☐	☐	☐	☐
Other safety investment	☐	☐	☐	☐	☐	☐	☐

B2: Direct costs incurred after all accidents in the last 5 years

What would you estimate as the total cost incurred by your organisation after all accidents in the last 5 years

	< £1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200000
9. Cost related to damaged materials/machinery	1	2	3	4	5
10. Cost related to litigation (fines & solicitors)	1	2	3	4	5
11. Cost related to medical care	1	2	3	4	5
12. Cost related to accident insurance premium	1	2	3	4	5
13. Cost related to accident compensation claim	1	2	3	4	5
14. Cost related to accident investigation	1	2	3	4	5
15. Others (please specify)………………………	1	2	3	4	5

B3: Indirect costs incurred after all accidents in the last 5 year

What would you estimate as the total cost incurred by your organisation after all accidents in the last 5years

	<£1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200,000
16. Lost time of other employees due to accident	1	2	3	4	5
17. Hiring cost of temporary tools and plant	1	2	3	4	5
18. Working day lost	1	2	3	4	5
19. Sick pay	1	2	3	4	5
20. Cleaning and waste disposal	1	2	3	4	5
21 Overtime working due to accidents	1	2	3	4	5
22. Others (please specify)………………………...	1	2	3	4	5

Section C: Benefits

Please estimate the total benefits accrued to your organisation as a result of the actions taken to prevent accidents in the last 5 years

	<£1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200000
23. Cost saving on insurance premium	1	2	3	4	5
24. Productivity improvement	1	2	3	4	5
25. Improved company image	1	2	3	4	5
26. Cost saving on compensation claim	1	2	3	4	5
27 Cost saving on medical care	1	2	3	4	5
28 Cost saving on damage materials/machinery	1	2	3	4	5
29 Cost saving on working day lost	1	2	3	4	5
30 Cost saving on sick pay	1	2	3	4	5
31 Cost saving in litigation (fines & solicitors)	1	2	3	4	5
32 Cost saving on accident investigation	1	2	3	4	5
33 Cost saving on safety training	1	2	3	4	5
34. Cost saving on lost time of other employees	1	2	3	4	5
35. Cost saving on cleaning and waste disposal	1	2	3	4	5
36. Cost saving on hiring of tools and plant	1	2	3	4	5
37. Other benefits (please specify)………………	1	2	3	4	5

ANY OTHER COMMENTS

Any other comments

………………………………………………………………...……………………………………………

Will you be available for a brief follow-up confidential interview?

Yes ☐

No ☐

Thank you for completing the questionnaire. Your answer will assist us in developing a cost-benefit analysis model for construction health and safety management.

Appendix B:

Qualitative Phase (Interviews)

School of Engineering and the Built Environment
Wolverhampton, WV1 1SB
United Kingdom

REQUEST FOR ASSISTANCE WITH RESEARCH INTO COST AND BENEFIT OF ACCIDENT PREVENTION ON CONSTRUCTION PROJECTS

I am a PhD student seeking to develop a Cost-Benefit Analysis (CBA) model for accident prevention on construction projects. The aim of this questionnaire is to gather and assesses experts' opinions for the attached developed conceptual framework, which is intended for assisting contractors in their decision making on investing in health and safety measures. This is meant for determining the suitability of the framework as to its significance to the development of a CBA model for accident prevention on construction project. Such a study requires input from industry experts whose contribution can make this research successful. It is in the light of this that I am seeking your contribution, as a health and safety expert, to this research by way of telephone interview, which will take no more than 20 minutes of your time. Your participation will be way of telephone interview, and this letter is to give prior notice of the interview. The telephone interview will be based on the framework developed for a CBA of accident prevention.

You are assured that the information obtained from this survey will be kept strictly confidential and used for research purpose only. We do appreciate that the interview will take some of your valuable time. However, without your kind and expert input, the ambitions of this research project will not be realised. It is our hope therefore that you will be able to assist us in this research.

The questionnaire is in two (2) parts, section **A** seeks to collect information on your background and is optional while section **B** ask for your opinion and comments on the developed framework.

Please return the completed questionnaire and indicate your convenient time you will be available for the interview in the self addressed stamped provided to the address below.

Elias Ikpe (Principal investigator)
School of Engineering and the Built Environment (SEBE)
University of Wolverhampton,
Wulfruna Street,
Wolverhampton.
WV1 1SB, UK
Tel: 07956879062: 01902518537:

Section A: General information

A1: Information about you (optional)

Name of respondent (Optional)---

Years of experience as Health and Safety practitioner---

Position in the organisation--

Name of organisation (Optional)--

Business address (Optional)--

Tel. (Optional)-----------------------------Fax-----------------------------------E-mail---

Section B:

1. What do you understand by the 'term' health and safety measures (cost of accident prevention)?

2. What aspect of health and safety measures is considered most important to your organization?

   First aid facility ☐ Personal protective equipment ☐ Safety training ☐ Safety promotion ☐Safety personnel ☐

3. What sort of health and safety measures do you invest much money on when undertaking your work?

   First aid facility ☐ Personal protective equipment ☐ Safety training ☐ Safety promotion ☐ Safety personnel ☐

4. Drawing from your experience on cost of accident prevention, what was the most cost of prevention to your organization?

   First aid facility ☐ Personal protective equipment ☐ Safety training ☐Safety promotion ☐ Safety personnel ☐

5 Drawing from your experiences on construction sites, do you think high investment on health and safety measures can lead to more benefits to contractors as stated in the developed framework?

Yes ☐ No ☐

6 Do you also think low investment on health and safety measures can lead to costs of accidents

Yes ☐ No ☐

7 In the last 12 months, did your organization incur any cost of accident?

Yes ☐ No ☐

If No to Q7, then go to Q8; if Yes, then go to Q9,

Yes ☐ No ☐

8 Was it because your organization invested more on health and safety measures to prevent accidents?

Yes ☐ No ☐

9 Was it because the health and safety measures were inadequate?

Yes ☐ No ☐

10. In your opinion, can costs of accident prevention stated in the developed framework lead to benefits of accident prevention to contractors and improve health and safety performance in the construction industry?

Yes ☐ No ☐

12. How would you describe health and safety performance in your organization?

Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor ☐

13 Do you feel that the information provided in the framework is useful?

Yes ☐ No ☐

14. Which aspects do you think are the most useful?

Cost of accident prevention☐ Benefits of accident prevention ☐

15 Which aspects do you think are the least useful?

Cost of accident prevention☐ Benefits of accident prevention ☐

16. Is there any other information you think would be valuable?

Yes ☐ No ☐

17. Do you feel that cost and benefit of accident prevention is an effective means to give you information on reducing costs of

accident?

Yes ☐ No ☐

18. Which do you feel contains the most useful information that has not been mentioned already

that you would find useful

19. If you were to undertake a similar investigation into costs and benefits of accident prevention on construction projects, what aspect of health and safety would you focus on?

Costs of accident ☐Benefits of accident prevention ☐ Costs of accident prevention ☐

20 Would you say the developed conceptual framework is capable of assisting contractors in their decision making?

Yes, highly capable ☐ Yes, capable ☐ No, not capable ☐ Not sure of its capability ☐

21 What is your opinion on the framework developed?

Very Suitable ☐ Suitable ☐Not suitable ☐ Not sure of its suitability ☐

22. What would you estimate as the total cost incurred by your organisation after all accidents in the last 12 months on cost related to accident insurance premium?”

23. Please provide any other general comments that you have on the framework or suggestions for improvement.

……

……

……

Thank you for taking your time

APPENDIX C:

Main Questionnaire Survey

School of Engineering and the Built Environment
Wolverhampton, WV1 1SB
United Kingdom

INVITATION TO PARTICIPATE IN A STUDY OF COST-BENEFIT ANALYSIS OF ACCIDENT PREVENTION ON CONSTRUCTION PROJECTS

The School of Engineering and the Built Environment, University of Wolverhampton is conducting a research study on construction health and safety management under the guidance of Dr Felix Hammond, Prof. David Proverbs Mr Keith Potts and Dr David Oloke. Specifically, the research aims to develop a cost-benefit analysis model to help provide a decision support tool to assist contractors and designers improve decision making in respect of health and safety issues/policies.

Your participation in this project is completely voluntary. It would be very much appreciated if you complete all parts of the questionnaire. Please note that any information you provide will be treated with the **strictest confidence**.

The questionnaire is in three (3) parts. **Section A** requests general information about you and the organisation. **Section B** requests information about accident costs and cost of implementing health and safety policies. **Section C** requests information about the benefits of accident prevention.

We do appreciate the questionnaire will take some of your valuable time, however, it will provide a tremendous contribution to the current study on measures to improve the overall health and safety performance of the construction industry. Without your kind and expert input the ambition of this research cannot be realised. Any further information and the final outcome of the research will be available upon your request. We hope to share the results by publishing them in journals and presenting them at conferences in the UK and overseas. To this end, we would like to thank you very much for your valued and kind consideration.
Please return completed questionnaire in the enclosed SAE or fax to:

Elias Ikpe (Principal investigator)
MA115
School of Engineering and the Built Environment (SEBE)
University of Wolverhampton,
Wulfruna Street,
Wolverhampton.
WV1 1SB, UK.
Tel: 07956879062: 01902321271:
Fax: 01902322743
E-mailElias.Ikpe@wlv.ac.uk

Section A: General information

A1: Information about you (optional)

Name of respondent (Optional) ____________________

Years of experience as Health and Safety practitioner ____________________

Position in the organisation ____________________

Name of organisation (Optional) ____________________

Business address (Optional) ____________________

Tel. (Optional) __________ Fax __________ E-mail __________

A2 . Please indicate the type of construction organisation your company is

1. Civil engineering contractor ☐
2. Building contractor ☐
3. Specialist subcontractor ☐
4. House builder ☐
5. Consultancy ☐
6. Building and Civil engineering contractor ☐
7. Demolition contractor ☐
8. Other (please specify) ☐

A3: Approximately how many employees are there in your organisation?

Full time……………………………………………………..

Part time……………………………………………………..

A4: Please give the size of your organisation in terms of annual turnover

< £5m	£6m – £10m	£11m – £25m	£26m - £100m	> £100m
☐	☐	☐	☐	☐

Section B: Costs

B1: Safety investment in the last 12 months

Please estimate how much your organisation spent on the following health and safety measures in the last 12 months

	< £1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200,000
1. Expenditure on safety first aid facilities	1	2	3	4	5
2. Expenditure on personal protective equipment (PPE) such as helmets etc.	1	2	3	4	5
3. Expenditure on health and safety promotion such as printing of pamphlets, posters etc.	1	2	3	4	5
4. Expenditure on health and safety training	1	2	3	4	5
5. Expenditure on health and safety personnel	1	2	3	4	5
6. How much did your organisation budget as expenditure on health and safety measures	1	2	3	4	5
7. Apart from these safety investment how much did your organisation spend as additional measure to reduce accidents	1	2	3	4	5
8. Others (please specify)……………………	1	2	3	4	5

B2: Direct costs incurred after all accidents in the last 12 months

What would you estimate as the total cost incurred by your organisation after all accidents in the last 12 months

	< £1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200000
9. Cost related to damaged materials/machinery	1	2	3	4	5
10. Cost related to litigation (fines & solicitors)	1	2	3	4	5
11. Cost related to medical care	1	2	3	4	5
12. Cost related to accident insurance premium	1	2	3	4	5
13. Cost related to accident compensation claim	1	2	3	4	5
14. Cost related to accident investigation	1	2	3	4	5
15. Others (please specify)………………………	1	2	3	4	5

B3: Indirect costs incurred after all accidents in the last 12 months

What would you estimate as the total cost incurred by your organisation after all accidents in the last 12 months

	<£1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200,000
16. Lost time of other employees due to accident	1	2	3	4	5
17. Hiring cost of temporary tools and plant	1	2	3	4	5
18. Working day lost	1	2	3	4	5
19. Sick pay	1	2	3	4	5
20. Cleaning and waste disposal	1	2	3	4	5
21 Overtime working due to accidents	1	2	3	4	5
22. Others (please specify)……………………...	1	2	3	4	5

Section C: Benefits
Benefits derived after all accidents prevention in the last 12 months

Please estimate the total benefits accrued to your organisation as a result of the actions taken to prevent accidents in the last 12 months

	<£1000	1,000-9,999	10,000-49,999	50,000-200,000	>£200000
23. Cost saving on insurance premium	1	2	3	4	5
24. Productivity improvement	1	2	3	4	5
25. Improved company image	1	2	3	4	5
26. Cost saving on compensation claim	1	2	3	4	5
27 Cost saving on medical care	1	2	3	4	5
28 Cost saving on damage materials/machinery	1	2	3	4	5
29 Cost saving on working day lost	1	2	3	4	5
30 Cost saving on sick pay	1	2	3	4	5
31 Cost saving in litigation (fines & solicitors)	1	2	3	4	5
32 Cost saving on accident investigation	1	2	3	4	5
33 Cost saving on safety training	1	2	3	4	5
34. Cost saving on lost time of other employees	1	2	3	4	5
35. Cost saving on cleaning and waste disposal	1	2	3	4	5
36. Cost saving on hiring of tools and plant	1	2	3	4	5
37. Other benefits (please specify)………………	1	2	3	4	5

ANY OTHER COMMENTS

……………………………………………………………..……………………………………………

………………………………………………………………..…………………………………………

Will you be available for a brief follow-up confidential interview?

Yes ☐

No ☐

Thank you for completing the questionnaire. Your answer will assist us in developing a cost-benefit analysis model for construction health and safety management.

APPENDIX D:

Validation Letter to Experts for Comments on Developed Models

School of Engineering and the Built Environment
Wolverhampton, WV1 1SB
United Kingdom

INVITATION TO PARTICIPATE AND PROVIDE SOME COMMENTS ON THE VALIDITY OF A CBA MODEL OF ACCIDENT PREVENTION ON CONSTRUCTION PROJECTS RESEARCH FINDINGS

You may recall the questionnaire survey on the costs and benefits of accident prevention construction projects that was sent to you for feedback some 17 months ago. Under the School of Engineering and the Built Environment, University of Wolverhampton this survey was carried out as part of a wider research work aimed at identifying current problems with accident prevention towards the development of an appropriate framework for improvement of health and safety management. The aim of this questionnaire is to gather and assess experts' opinions on the attached model, which is intended for assisting contractors in the decision making on costs and benefits of accident prevention on construction projects. This is meant for validating the proposed model as to its significance to the industry, workability in practice and adequacy in addressing the decision problem confronting contractors on accident prevention

I am seeking your contribution, as a health and safety expert, to this research by way of telephone interview, which will take no more than 30 minutes of your time. Your participation will be way of telephone interview, and this letter is to give prior notice of the interview. The telephone interview will be based on the developed CBA model of accident prevention.

You are assured that the information obtained from this survey will be kept strictly confidential and used for research purpose only. We do appreciate that the interview will take some of your valuable time. However, without your kind and expert input, the ambitions of this research project will not be realised. It is our hope therefore that you will be able to assist us in this research.

The questionnaire is in two (2) parts. **Section A** seeks to collect information on your background; **Section B** ask for your opinions or comments on general and specific aspects of the model, respectively. There are no correct or incorrect responses, only your much-needed opinion.

Elias Ikpe (Principal investigator)
MI 202
School of Engineering and the Built Environment (SEBE)
University of Wolverhampton,
Wulfruna Street, Wolverhampton.
WV1 1SB, UK.
Tel: 07956879062: 01902321271:
Fax: 01902322743
E-mail: Elias.Ikpe@wlv.ac.uk

Section A: Background of Respondent

General information
Please indicate your

Name (optional)……………………………………………………………………………………

Please indicate your **position**
……………………………………………………………………………………………………

How many **years of experience** do you have in construction …………………………………………

Section B: General Impression on the model

1. The research found that costs of accident prevention influence benefits of accident prevention on construction sites. From your experience, how valid is this finding?

- yes, highly valid ☐
- yes, valid ☐
- no, not valid ☐
- not sure ☐

2. The research found that CBA approach can help to demonstrate that the costs of accident prevention can be offset by benefits accruing from accident prevention. From your experience, how valid is this finding?

- yes, highly valid ☐
- yes, valid ☐
- no, not valid ☐
- not sure ☐

3. The research found that the benefits of accident prevention far outweigh the costs of accident. From your experience, how valid is this finding?

- yes, highly valid ☐
- yes, valid ☐
- no, not valid ☐
- not sure ☐

4. The research found that greater expenditure on accident prevention improves safety performance on construction sites. From your experience, how valid is this finding?

- yes, highly valid ☐
- yes, valid ☐
- no, not valid ☐
- not sure ☐

5. Does the model address an important problem on cost of accident prevention (health and safety measures) in the construction industry?

- yes, quite significant ☐
- yes, but not significant ☐
- no, would make no difference ☐
- not sure of its significance ☐

6. Would you say the model is capable of assisting contractors on cost of accident prevention decision making?

- yes, highly capable ☐
- yes, capable ☐
- no, not capable ☐
- not sure of its capability ☐

7. Would you say the model is simple, clear and easy to understand?

- Yes ☐
- No ☐

8. If **No** to **Q9**, please comment on the specific aspects of the model that, in your view, are likely to cause major difficulties to its use.

……
…….

9. What is your opinion on the description of the model?

- comprehensive ☐
- adequate ☐
- poor ☐

10. In your opinion, are there any further matters of importance which ought to be included in the model or considered?

- Yes ☐
- No ☐

11. If **Yes** to **Q10**, please specify:

…….
……

12. Please provide any other general comments that you have on the model or suggestions for improvement (continue on a separate sheet if necessary)

……………………………………………………………………………………………….................
……

Thank you very much for your time

Appendix E:

Table 1 Costs of Accident Prevention Ratio

			Mean	Median	Standard Deviation
Size of contractors	0 - 49 = Small contractors	Turnover to first aid ratio	4198.17	5000.00	2260.30
		turnover to safety promotion ratio	5768.40	5000.00	6151.74
		turnover to training ratio	1811.59	454.59	2589.11
		safety personnel salary	2406.12	454.59	2767.96
		Turnover to PPE ratio	4236.97	5000.00	6286.45
		Turnover to Total cost of prevention	**376.62**	**143.87**	
	50 - 249 = Medium contractors	Turnover to first aid ratio	8575.16	3273.02	9181.77
		turnover to safety promotion ratio	10031.82	3273.02	10748.31
		turnover to training ratio	2442.10	600.01	4573.86
		safety personnel salary	1623.50	600.01	3431.13
		Turnover to PPE ratio	14050.06	1454.68	43437.36
		Turnover to Total cost of prevention	**382.57**	**170.22**	
	>250 = Large contractors	Turnover to first aid ratio	18223.15	3333.39	45300.23
		turnover to safety promotion ratio	8454.73	3333.39	7476.46
		turnover to training ratio	2078.78	800.00	3530.50
		safety personnel salary	1431.15	800.00	2288.99
		Turnover to PPE ratio	3871.14	2100.04	5188.48
		Turnover to Total cost of prevention	**272.11**	**241.96**	

Appendix E:

Table 2 Direct Benefits of Accident Prevention Ratio

			Mean	Median	Standard Deviation
Size of contractors	0 - 49 = Small contractors	turnover to saving insurance premium	3815.63	454.59	6803.27
		turnover to productivity improvement	2227.71	454.59	3590.45
		turnover to saving on compensation claim	7390.66	454.59	22310.31
		turnover to saving on medical care	7250.77	454.59	22340.25
		turnover to saving on damage material	8539.50	5000.00	22024.99
		turnover to saving on litigation	4446.16	5000.00	6689.92
		turnover to saving on accident investigation	3937.07	5000.00	6362.79
		turnover to safety training	3646.05	454.59	6840.76
		Turnover to Total direct benefit	**309**	**57**	**526**
	50 - 249 = Medium contractors	turnover to saving insurance premium	4456.91	800.00	10539.63
		turnover to productivity improvement	2540.58	504.00	7728.37
		turnover to saving on compensation claim	5348.78	315.00	11115.86
		turnover to saving on medical care	7086.93	600.01	12872.07
		turnover to saving on damage material	15082.74	3273.02	27712.82
		turnover to saving on litigation	6933.07	600.01	12811.79
		turnover to saving on accident investigation	5668.15	1454.68	10833.90
		turnover to safety training	7226.44	600.01	12810.75
		Turnover to Total direct benefit	**374**	**55**	**991**
	>250 = Large contractors	turnover to saving insurance premium	25092.48	3333.39	58160.09
		turnover to productivity improvement	14225.53	2100.04	34214.53
		turnover to saving on compensation claim	8510.35	800.00	25114.70
		turnover to saving on medical care	22667.60	3333.39	50183.15
		turnover to saving on damage material	36405.60	3333.39	63365.25
		turnover to saving on litigation	21665.46	3333.39	50459.02
		turnover to saving on accident investigation	26461.92	3333.39	57825.46
		turnover to safety training	31070.05	3333.39	61021.02
		Turnover to Total direct benefit	**1018**	**190**	**3109**

Appendix E:

Table 3 Indirect Benefits of Accident Prevention Ratio

			Mean	Median	Standard Deviation
Size of contractors	0 - 49 = Small contractors	turnover to company image	2069.01	454.59	3224.86
		turnover to saving on working day lost	3767.50	1454.68	6406.18
		turnover to saving on sick pay	3214.62	454.59	6474.61
		turnover to lost time of employees	4090.88	454.59	6752.02
		turnover to cleaning/waste disposal	8548.83	5000.00	22021.40
		turnover to saving on hiring of tools	7977.29	5000.00	22171.40
		Turnover to Total indirect benefit	**1325**	**833**	**3673**
	50 - 249 = Medium contractors	turnover to company image	2559.64	266.67	7743.08
		turnover to saving on working day lost	3082.02	600.01	7938.01
		turnover to saving on sick pay	8947.58	1454.68	27884.28
		turnover to lost time of employees	7249.63	2100.04	11046.89
		turnover to cleaning/waste disposal	13004.47	3273.02	28075.62
		turnover to saving on hiring of tools	13022.47	3273.02	28071.93
		Turnover to Total indirect benefit	**2111**	**643**	**3020**
	>250 = Large contractors	turnover to company image	10166.29	504.00	25263.07
		turnover to saving on working day lost	9931.92	3333.39	24976.93
		turnover to saving on sick pay	18818.65	3333.39	45195.81
		turnover to lost time of employees	17012.28	3333.39	33579.99
		turnover to cleaning/waste disposal	40868.05	11455.59	68451.48
		turnover to saving on hiring of tools	24980.28	3333.39	49454.20
		Turnover to Total indirect benefit	**2348**	**939**	**4352**

Appendix E:

Table 4 Total Benefits of Accident Prevention Ratio

Table 1

			Mean	Median	Standard Deviation
Size of contractors	0 - 49 = Small contractors	Turnover total direct benefits	309	57	526
		Turnover total indirect benefits	1325	833	3673
		Turnover total benefits	**205**	**53**	**416**
	50 - 249 = Medium contractors	Turnover total direct benefits	374	55	991
		Turnover total indirect benefits	2111	643	3020
		Turnover total benefits	**151**	**47**	**223**
	>250 = Large contractors	Turnover total direct benefits	1018	190	3109
		Turnover total indirect benefits	2348	939	4352
		Turnover total benefits	**607**	**134**	**1777**

Appendix F

Table 1 Cost of Accident Prevention

Kruskal Wallis

Ranks

	Size of contractors	N	Mean Rank
Turnover to first aid ratio	0 - 49 = Small contractors	33	40.11
	50 - 249 = Medium contractors	21	40.69
	>250 = Large contractors	25	39.28
	Total	79	
Turnover to PPE ratio	0 - 49 = Small contractors	33	41.44
	50 - 249 = Medium contractors	21	37.76
	>250 = Large contractors	25	39.98
	Total	79	
turnover to safety promotion ratio	0 - 49 = Small contractors	33	39.52
	50 - 249 = Medium contractors	21	39.52
	>250 = Large contractors	25	41.04
	Total	79	
turnover to training ratio	0 - 49 = Small contractors	33	31.91
	50 - 249 = Medium contractors	21	42.60
	>250 = Large contractors	25	48.50
	Total	79	
safety personnel salary	0 - 49 = Small contractors	33	39.62
	50 - 249 = Medium contractors	21	36.02
	>250 = Large contractors	25	43.84
	Total	79	

Appendix F:

Table 2 Direct Benefits Ranks

Kruskal- Wallis

	Size of contractors	N	Mean Rank
turnover to saving insurance premium	0 - 49 = Small contractors	33	36.58
	50 - 249 = Medium contractors	21	30.55
	>250 = Large contractors	25	52.46
	Total	79	
turnover to productivity improvement	0 - 49 = Small contractors	33	33.24
	50 - 249 = Medium contractors	21	33.17
	>250 = Large contractors	25	54.66
	Total	79	
turnover to saving on compensation claim	0 - 49 = Small contractors	33	39.09
	50 - 249 = Medium contractors	21	32.29
	>250 = Large contractors	25	47.68
	Total	79	
turnover to saving on medical care	0 - 49 = Small contractors	33	35.11
	50 - 249 = Medium contractors	21	34.76
	>250 = Large contractors	25	50.86
	Total	79	
turnover to saving on damage material	0 - 49 = Small contractors	33	36.29
	50 - 249 = Medium contractors	21	40.12
	>250 = Large contractors	25	44.80
	Total	79	
turnover to saving on litigation	0 - 49 = Small contractors	33	39.50
	50 - 249 = Medium contractors	21	33.81
	>250 = Large contractors	25	45.86
	Total	79	
turnover to saving on accident investigation	0 - 49 = Small contractors	33	36.86
	50 - 249 = Medium contractors	21	33.64
	>250 = Large contractors	25	49.48
	Total	79	
turnover to safety training	0 - 49 = Small contractors	33	33.58
	50 - 249 = Medium contractors	21	34.74
	>250 = Large contractors	25	52.90
	Total	79	

Appendix F

Table 3 Indirect Benefits Ranks

Ranks

Kruskal- Wallis

	Size of contractors	N	Mean Rank
turnover to company image	0 - 49 = Small contractors	33	35.29
	50 - 249 = Medium contractors	21	32.81
	>250 = Large contractors	25	52.26
	Total	79	
turnover to saving on working day lost	0 - 49 = Small contractors	33	38.94
	50 - 249 = Medium contractors	21	30.64
	>250 = Large contractors	25	49.26
	Total	79	
turnover to saving on sick pay	0 - 49 = Small contractors	33	32.91
	50 - 249 = Medium contractors	21	36.07
	>250 = Large contractors	25	52.66
	Total	79	
turnover to lost time of employees	0 - 49 = Small contractors	33	34.29
	50 - 249 = Medium contractors	21	36.36
	>250 = Large contractors	25	50.60
	Total	79	
turnover to cleaning/waste disposal	0 - 49 = Small contractors	33	36.64
	50 - 249 = Medium contractors	21	33.50
	>250 = Large contractors	25	49.90
	Total	79	
turnover to saving on hiring of tools	0 - 49 = Small contractors	33	36.00
	50 - 249 = Medium contractors	21	35.90
	>250 = Large contractors	25	48.72
	Total	79	
	>250 = Large contractors	3	2.33
	Total	4	

Appendix G:

Pearson's Correlation Matrix

Correlations

		Totalbenefit	first aid facilities cost	personnel protective equipment	Safety promotion	Safety training cost	safety personnel salary
Totalbenefit	Pearson Correlation	1.000	.				
	Sig. (2-tailed)						
first aid facilities cost	Pearson Correlation	.598**	1.000				
	Sig. (2-tailed)	.000					
personnel protective equipment	Pearson Correlation	.663**	.747**	1.000			
	Sig. (2-tailed)	.000	.000				
Safety promotion	Pearson Correlation	.669**	.723**	.750**	1.000		
	Sig. (2-tailed)	.000	.000	.000			
Safety training cost	Pearson Correlation	.616**	.667**	.754**	.725**	1.000	
	Sig. (2-tailed)	.000	.000	.000	.000		
safety personnel salary	Pearson Correlation	.462**	.591**	.585**	.637**	.720**	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).