Barriers to safety implementation: A cost-benefit analysis

By

Shamraiza Khan

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Submitted by

Shamraiza Khan

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Dr. Muhammad Jamaluddin Thaheem

Supervisor,

Department of Construction Engineering and Management

NIT, National University of Science and Technology (NUST), Islamabad

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Signature: ______________________________

Name of Supervisor: Dr. Muhammad Jamaluddin Thaheem

Date: __________________________________

Signature (HOD): _______________________

Date: __________________________________

Signature (Dean/Principal): _______________

Date: _________________________________

Dedicated to my parents and teachers who have been an inspiration to me

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Abstract

Occupational health and safety within any organization is very important as each person on work site or in office has the right to go home safely. Unfortunately, worker safety is not dealt with much care in the construction sector. Due to unavailability or weak regulation, construction businesses prefer profit over workers' life. Several accidents, near misses and fatalities are reported each year at construction sites. Since construction industry is vital to a country's economy, a proper mechanism by which occupational safety can be implemented is the need of hour. With an aim to find the barriers to safety implementation and figure out the financial benefits of such implementation, this study identifies a number of safety barriers and percentages of different safety cost through literature review. Further, data is collected from industry on the identified barriers and cost of safety is acquired from experts through questionnaire survey. Afterwards, impact of barriers on safety cost is studied to highlight the benefits which can be reaped by proper safety implementation. To validate the effectiveness of safety investment, a cost-benefit analysis is performed on real projects and safety implementation strategies are developed to help construction industry effectively and beneficially implement safety.

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Chapter 1

Introduction

1.1 Background

Construction industry play a vital role in country's financial growth as presence of buildings and infrastructure depicts country's development. In addition, innovations and new ideas require cooperation and coordination of members of an organization is also important towards country's success (Ishkov et al., 2016). Nature of construction industry is complex as it involves several stakeholders having different perception to achieve project goals. To realize any project success a team is formed consists of subcontractors, workers, masons, vendors, etc. and their safety is duty of top management. Knowing importance of construction industry in country's progress, safety practices of workers within organization in providing construction projects is not given much importance, and service of appropriate safety measures throughout construction is considered a load (Mohamed and Ali, 2005).

Construction industry is the most unsafe industry (Perttula et al., 2006; Pinto et al., 2011). In total, 21% of accidents and fatalities are investigated on construction sites (Ogwueleka and Mendie, 2014). For construction workers, the probability of fatality is three times higher and injury is two times higher than any employee of other industry (Sousa and Teixeira, 2004). It hires a larger percentage of workers than other industrial sector (ETA/Business Relation Group Report, 2004). Construction industry consists of 7% of the global workforce and is accountable for 30-40% of casualties (Sunindijo and Zou, 2012). The environment of construction industry involves unsafe acts and appropriate understanding of safety management is required to manage hazards and increase project accomplishment (Ogwueleka and Mendie, 2014).

Safety practices of developed countries have been improved with time and they have organizations for its implementation, while developing countries are still behind in this regard. Accident information is neither recorded nor reported to the monitoring agencies (Raheem and Issa, 2016b). Due to the absence of safety policies, ineffectiveness of the regulatory authority and poor assessment of occupational safety have become major issues (Ali, 2006). According to a study by Zahoor et al. (2016), due to more dependency on labor force rather than latest equipment, technical development could not enhance safety performance in construction industries.

Safety rules are merely prepared for the sake of documentation and not properly implemented on construction sites (Zahoor et al., 2016). Safety manual is only present in few large construction companies, majority of the contractors do not have their safety manual, and even if they have, it is not updated frequently (Raheem and Hinze, 2012). A lot of work on many topics has been done but they mostly cover specific aspects rather than comprehensive work (Zhou et al., 2015). It can be seen that safety investments had been ignored in past and this had a major impact on safety management from construction viewpoint and worker's performance (Elias Ikpe et al., 2012). Tang et al. (2004) reveals that various benefits could be achieved through better investment in safety. Using cost-benefit analysis; Elias Ikpe et al. (2012) showed that revenue of accident avoidance counterbalances the cost of accident prevention by a ratio of approximately 3:1. Thus it can be seen that safety investments result in reduced number of deaths, less injuries and accidents (Brent, 2003). According to Shearn (2003) these profits can give both direct and indirect corporate benefits. With awareness of these benefits of accident avoidance, contractors may be encouraged to spend more on health and safety.

In spite of much research on safety, present condition of Pakistani construction industry is not satisfactory because there is no strategy to implement it. To make matters worse stakeholders are usually nonflexible to build safety policy because they are uncertain about its effectiveness (Raheem and Issa, 2016b). However ‘a detailed study is required to determine the barriers to safety implementation’ (Zahoor et al., 2016). For making safety situation better in Pakistani construction industry, a safety implementation strategy needs to be developed along with a proper mechanism to judge the success of implementation plan. The cost of safety implementation and its associated benefits must be incorporated to validate financial viability of the proposed plan.

1.2 Selection of topic

Due to increased safety concern in construction industry it is essential to find out barriers to implement safety practices and ultimately compromising workers’ life for project accomplishment. Everyone talks about safety but no one stands for it so we need a proper mechanism for safety implementation in construction industry of developing countries. Knowing the reasons which hinder to apply safety we can better implement it and a proper monitoring system is needed that ensures the effectiveness of strategy and calculating its cost change the mindset of construction employ that safety only adds money to project rather it saves money which is required for insurance, injury or accidents etc.

1.3 Research Objectives

- To identify barriers to safety implementation.
- To estimate the cost of safety implementation and associated benefits.
- To develop a safety implementation strategy.

1.4 Significance of This Study

Modern technical change and novel ideas are key factors for growth of any industry. Construction industry, the ever-growing industry, is unlucky in having the ability to adopt these factors because of a large number of stakeholders (primary and secondary) due to which problems in communication arises, resulting time and cost delay (Kazmi, 2014)

Construction activities are important for development goals like provision of refuge, transportation and services. At same time, it is most hazardous industry with greater percentage of fatality and accidents. Suitable safety equipment's are needed to reduce the risk of accident. Since accidents have negative impact on company's reputation it is necessary to ensure safety policies for organization. Success of any construction project is based on factors like cost, schedule, performance and safety (Hughes et al., 2004). Cost and schedule are considered most important for any project success, at the same time safety is ignored however, it is also a vital factor for a project to be completed successfully. For construction to well perform its role, safety must be considered core component for industry. Safety is given importance only for the sake of documentation but it is not applied in any project. It has gained importance among academics and practitioners so by finding out the barriers for safety implementation, calculating its cost and proposing a strategy for its application will help industry to gain a better position worldwide. By adopting such practices will increase the awareness among the stakeholders. This will help develop our country and make better position in international market.

1.5 Scope:

Scope of this research covers safety conditions of construction industry in developing countries. It covers areas of planning, designing, scheduling, construction, supervision, goods supply and monitoring and control.

An effort is made to cover all field players involved in construction safety management. This research will contribute in adopting safety measures in construction industry and will help in minimizing overruns and increasing profits.

Chapter 2

Literature Review

2.1 Construction industry from safety perspective

Construction industry within any state shows progress of economic growth as it offers foundation for other sectors to grow. More workers are employed by construction companies with their knowledge ranging from universal labor to workers with limited knowledge, experienced and professional experts (Mohamed and Ali, 2005). During past few years, it is seen that construction industry rose the gross domestic product (GDP) from 2.42% to 2.58%, demonstrating its significant involvement in country's economic expansion (Zahoor, 2017).

Construction industry is complex industry aiming to produce a unique product, because of its complexity it faces more workplace accidents, injuries, fatalities, etc. than other industries (López-Alonso et al., 2013b). In spite of its importance in country's financial and social development, it is most accident-prone industry in the world. It has larger amount of severe injuries, accidents, fatalities and near misses (Kines et al., 2010) and safety of employees is not a top consideration. Within construction sector, millions of work-related accidents and diseases are reported each year. The rising number of injuries has increased the concern for workers' health and safety (Nassiri et al., 2015).

According to Gambatese et al. (2017)"Safety First" and "Safety is #1" mottos are reported. It is seen that construction workers' performance toward safety has been improved over last few years but is still behind many industries of other sectors. Every person on worksite deserves a safe working atmosphere which facilitates them to live a socially and reasonably successful life (Loosemore and Andonakis, 2007).

Consequences of substandard safety behavior are accidents, damages and death, and as an outcome of this, there is shortage of workers from site of construction project, less courage of workers, late work completion, high cost, and disputes between project team. It result in damage to the profitability and productivity of a project (Zahoor et al., 2016). Poor safety practices result in accidents causing detrimental effect on output efficiency, assets, resources and courage of workers, which ultimately have negative impact on company's revenue, cost and expenses. Feng (2013) highlighted the relation between safety cost, culture and level of project complexity results in accidents on construction site. Cost of accidents are as high as 3% of total cost of a project and serves as an inspiring factor to improve safety in order to reduce overall cost (Feng et al., 2015). According to López-Alonso et al. (2013b), as percentage of worker increases, number of accidents also increases resulting in high cost for project, while it is inversely related to cost of accident prevention. Investing money in worker safety helps in preventing accidents, injuries and fatalities. Practically decisions are made in advance to spend on safety measures to avoid future circumstances. Decisions are based on experience, previous knowledge, and accident history of company. Typically, probability of accidents indicates expense of safety. More possibility of accidents results in more funds because decision is based on prediction, so it involves uncertainties (Sato, 2012).

Zahoor et al. (2016) suggested that to recover from loses because of poor safety practices various efforts have been done by different countries to improve health and safety of workers and to reduce injuries, fatalities and accidents. Worker safety is treated with extreme care and caution in the developed countries. Departments like Occupational Safety and Health Administration (OSHA) in United States of America and Labor department in Hong Kong are determined to achieve zero-accident rate (Choudhry et al., 2009). Safety is considered most important concern for developing countries, due to weak policymaking and administration. The insufficiency of rules and regulations, commercially weak principals and authority, large number of workforce and insufficient facilities are a few reasons for poor safety in most emerging economies. Unfortunately, it is difficult to implement the current safety practices of other industries to construction industry, because lack of safety rules and regulation negatively affects safety implementation, causing unfavorable situations for workers' safety (Mohamed and Ali, 2005).

2.2 Construction safety culture

Safety is a practical, managerial or shared task and used to lower the chances of any useless activity that causes accidents or injuries in an organization (Harms-Ringdahl, 2009).

In construction industry, involvement of different parties (owner, designer and contractor) having different culture, is necessary to realize project success. They collaborate to give a desired product/service. Project team is responsible for healthy and safe environment for employees, with differing roles towards safety, in preventing accidents and to achieve a safe environment (Huang and Hinze, 2006). Organizational features such as workers, environment, policies and practices reflect their safety culture. Within any firm, project teams involve members with skill who create good working situation through joint effort to maximize their strengths and minimize weakness. So, it is a described as mutual views/understandings between workers regarding safety problems in their teams (Li et al., 2017). Workplace safety of an organization is affected by its structure, verbal capability, clear orders, rules and regulations, practices, etc.

For safety of workers, organizational culture and human factors are equally important as improved working conditions and innovation in equipment are necessary (Zhou et al., 2008). According to Choudhry et al. (2007) constructive safe atmosphere enhance performance of workers on project. For construction industry, safety culture is gaining importance. Safety culture is influenced by demographic factors like maturity, learning, understanding, employment, marital status, behavior, etc. Workers having families and responsibilities show positivity about safety while workers with no family responsibility are less worried about their safety (Choudhry et al., 2009).

2.3 Barriers to safety implementation

A barrier represents an obstruction in realizing set goals (Lindoee and Stene, 2011). In literature, it is also used as hindrance, difficulty and problem (Sevcik and Gudmestad, 2014). Raheem and Hinze (2012) suggested that despite the presence of safety rules and regulations, their implementation within construction industry is limited and difficult. This is not just because of weak legal rules but also due to socio-economic factors prevalent in the industry. Other reasons for poor safety on site are disintegrated and difficult nature of construction site, poor risk catering on a site that keeps on changing, and involvement of project parties with differing aims and goals (Gambatese et al., 2017).

In order to develop an exhaustive list of barriers to safety implementation, a detailed literature review has been performed. In doing so, a total of 15 published research papers were thoroughly reviewed to extract a total of 33 barriers given in Table 1. By performing a content analysis, the influence of identified barriers is evaluated. The content analysis is performed in two phases: a quantitative analysis which considers the frequency of appearance of a barrier in the selected papers; and a qualitative analysis which evaluates a barrier's significance on a 3-point Liker scale (5 = High, 3 = Medium and 1 = Low). Using a product of normalized scores, a literature score is obtained and the barriers are ordered according to this score. Also, language and educational barriers, limited resources, safety investment and nature of construction contracts are found to be the most critical factors obstructing safety implementation within construction industry while worker's dissatisfaction with safety training, work on piecework costs and lack of union representation are the least critical reasons.

Table 1: Safety barriers from literature

No.	Code	Barriers	Literature Score	Selected References
1	B1	Language and educational barriers of workers, architects and designers	0.5	Hon et al. (2012), Masood and Choudhry (2012), Lingard (2013), Sousa et al. (2014)
2	B2	Limited safety resources	0.2857	Hasle et al. (2010), Huang and Hinze (2006), Sinelnikov et al. (2015), Gambatese et al. (2005b)
3	B3	Safety investment	0.2857	Hon et al. (2012), Huang and Hinze (2006), Loosemore and Andonakis (2007), Sinelnikov et al. (2015)
4	B4	Nature of construction contracts	0.2143	Behm (2005), Lingard (2013), Gambatese et al. (2005b)
5	B5	Additional cost to design for safety	0.2143	Gambatese et al. (2017), Lingard (2013), Behm (2005)
6	B6	Verbal and mental inability of workers	0.2143	Loosemore and Andonakis (2007), Lingard (2013), Sousa et al. (2014)
7	B7	Legal and liability issues	0.1429	Behm (2005), Gambatese et al. (2005b)
8	B8	Weak or absent regulatory requirements	0.1429	Behm (2005), Gambatese et al. (2005b)
9	B9	Mindset of workers of small and medium enterprises (SMEs)	0.1429	Hasle et al. (2010), Hon et al. (2012)
10	B10	Culture of risk transfer	0.1429	Loosemore and Andonakis (2007), Behm (2005)
11	B11	Migrant workforce	0.1429	Loosemore and Andonakis (2007), Trajkovski and Loosemore (2006)
12	B12	Less awareness about role of stakeholders	0.1429	Raheem and Hinze (2012), Sinelnikov et al. (2015)
13	B13	Ineffective training of safety personnel	0.1429	Raheem and Hinze (2012), Gambatese et al. (2005b)

14	B14	Less legal binding towards safety	0.1429	Raheem and Hinze (2012), Gambatese et al. (2017)
15	B15	Conflicts with contract conditions	0.1429	Toole (2005), Behm (2005)
16	B16	Difficulty in performing safety management	0.0714	Hasle et al. (2010)
17	B17	Adding new scope to the project	0.0714	Huang and Hinze (2006)
18	B18	Increasing the speed of construction activity	0.0714	Huang and Hinze (2006)
19	B19	Traditions for new improvement scheme	0.0714	Loosemore and Andonakis (2007)
20	B20	Less formal training of stakeholders	0.0714	Raheem and Hinze (2012)
21	B21	Need of officially authorized infrastructure	0.0714	Raheem and Hinze (2012)
22	B22	Methods to integrate safety into company's culture	0.0714	Raheem and Hinze (2012)
23	B23	Less attention to safety in standard contract	0.0714	Raheem and Hinze (2012)
24	B24	Less detail of record keeping	0.0714	Raheem and Hinze (2012)
25	B25	Coordination between project manager (PM) & safety officer (SO)	0.0714	Raheem and Hinze (2012)
26	B26	Inappropriate knowledge of wearing PPE	0.0714	Raheem and Hinze (2012)
27	B27	Unclear language of bidding document	0.0714	Raheem and Hinze (2012)
28	B28	High cost of training and implementation	0.0714	Raheem and Hinze (2012)
29	B29	Incompetency of safety knowledge	0.0714	Toole (2005)
30	B30	Less awareness of construction work	0.0714	Toole (2005)
31	B31	Worker's dissatisfaction with safety training	0.0429	Sinelnikov et al. (2015)
32	B32	Work on piecework costs	0.0429	Loosemore and Andonakis (2007)
33	B33	Lack of union representation	0.0429	Loosemore and Andonakis (2007)

2.4 Cost of safety implementation

SC is the money spent to place stress on safety management, trainings, incentives, safety personnel, equipment for personnel protection or other acts. All these are the ways to reduce accidents and improve worker performance (Feng et al., 2014). Investing money for health and safety had been ignored previously by construction sector, and it had a major impact on construction process, worker performance and safety management (Kheni et al., 2010).

SC is divided into different categories by different authors which have been synthesized in Table 2. A total of 18 categories are identified and maximum number of categories used by any author are nine (Elias Ikpe et al., 2012) while least used are two (Cheng et al., 2010; Oxenburgh and Marlow, 2005; Tang et al., 2004; Vatani et al., 2016). Most of the studies classified SC into prevention (C15), accident (C16), direct (C17) and indirect (C18) costs. According to Oxenburgh and Marlow (2005), money spent to avert any accident is known as cost of accident prevention (C15). It is not included in the bid price but is an additional expense for the contractors which is agreed between owner and contractor at start of project (Elias Ikpe et al., 2012). Mathematically given in Equation 1, accident prevention cost (π) consists of different protective measures, such as training (τ), first aid (fa), safety equipment (se), promotions (Φ) and safety personnel (sp), taken for betterment of workers.

$$\pi = \tau + fa + se + \Phi + sp \qquad \textbf{\textit{Equation 1}}$$

Further, accident cost (C16) incurs in case an accident occurs, regardless of the existence of safety practices. It is related to the project, always adds into the total project cost (TPC) and is charged from the contractor (Elias Ikpe et al., 2012). On the other hand, direct cost (C17) is the amount directly charged for accidents or in result of poor safety.

Table 2: Health and safety cost categories

Reference	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Total categories
Elias Ikpe et al. (2012)								✓	✓	✓			✓	✓	✓	✓	✓	✓	9
Feng (2013)					✓	✓	✓				✓	✓	✓	✓					7
Ibarrondo-Dávila et al. (2015)		✓							✓	✓	✓				✓	✓			6
Gurcanli et al. (2015)								✓					✓	✓	✓	✓			5
Feng et al. (2015)															✓	✓	✓	✓	4
Pellicer et al. (2014)	✓			✓											✓	✓			4
Lebeau et al. (2014)												✓					✓	✓	3
Waehrer et al. (2007)			✓														✓	✓	3
Vatani et al. (2016)																	✓	✓	2
Cheng et al. (2010)															✓	✓			2
Oxenburgh and Marlow (2005)																	✓	✓	2
Tang et al. (2004)																	✓	✓	2
Total	1	1	1	1	1	1	1	2	2	2	2	2	3	3	6	6	7	7	

C1: Recovery of costs; C2: Non-safety cost; C3: Quality of life cost/pain of suffering cost; C4: Insurance costs; C5: Staffing cost; C6: Inspection & meeting cost; C7: Promotion & incentive cost C8: Collective protection measures C9: Tangible cost; C10: Intangible cost; C11: Safety cost; C12: Innovation cost; C13: Personal protective equipment (PPE); C14: Safety training; C15: Prevention cost; C16: Accident cost; C17: Direct Cost; C18: Indirect cost

It includes hospital and medical bills, recuperation, health care, medical equipment, funeral costs, indemnification costs for medical claims, expenses for mental health treatment, police, fire, emergency transport and possessions harm (Vatani et al., 2016; Lebeau et al., 2014; Feng et al., 2014; Feng et al., 2015). Finally, indirect cost (C18) is related to unbudgeted costs associated with an injury to get the worker back to pre-injury position. It is not directly charged because of bad safety practices such as productivity loss, household production loss, sick leaves, etc. (Waehrer et al., 2007; Tang et al., 2004; Ikpe et al., 2008).

Many researchers have calculated different SC percentages as per their studies which are synthesized in Table 3. It is seen that there is a vast variance in TSC, the maximum is found to be 8-15% and minimum is 0.8-1.5%. This difference is due to type of study in which some researchers considered projects for a certain period (Tang et al., 2004), small and medium residential projects (Gurcanli et al., 2015), building projects (Feng et al., 2015), etc.

Table 3: Percentage of safety cost

Reference	TPC	SC	C1	C4	C15	C16	C17	C18
Rajendran et al. (2017)	$115 Million	5-6%	-	-	5-6%	-	-	-
Vatani et al. (2016)	$45 Million	1.16%	-	-	-	-	-	-
Feng et al. (2015)	-	-	-	-	-	0.26%	0.17%	0.09%
Gurcanli et al. (2015)	$69 Million	1.9%	-	-	-	-	-	-
Ibarrondo-Dávila et al. (2015)	$470 Million	7.51%	-	-	-	-	-	-
Zhou et al. (2015)	-	2.28%	-	-	-	-	-	-
Pellicer et al. (2014)	$23 Million	~ 5%	0.29%	2.6%	1.5%	0.93%	-	-
Ikpe et al. (2008)	-	6%	-		2.5%	-	-	-
Oxenburgh and Marlow (2005)	$3071/yr	~ 3.13%	-	-	-	-	-	-
Rikhardsson and Impgaard (2004)	-	-	-	-	-	2%	-	-
Tang et al. (2004)	-	0.8%-1.5%	-	-	-	-	-	-
Tang et al. (1997)	-	> 0.8%	-	-	-	-	-	-
Everrat and Frank (1996)	-	7.9%-15%	-	-	-	7.9%-15%	-	-

Laufer (1987)	-	6%	-	-	2.5%	-	-	-
Levitt et al. (1981)	-	6.5%	-	-	-	-	-	-

Ibarrondo-Dávila et al. (2015) developed a management accounting model for construction companies that will help in decision-making process of safety management. SC was categorized into safety cost (C14) and non-safety cost (C7). For this 40 construction sites were taken and model based on equation was established and it is validated using 2 case studies. SC found to be 7.5% of TPC. Similarly, Pellicer et al. (2014) calculated SC by developing a model having mathematical formulation. SC was classified into insurance cost (C4), prevention cost (C15), accident cost (C17) and recovery of cost (C1). For doing so, projects of Spanish construction industry for a period of a period of 17 years were critically reviewed. Based on data obtained from 89 projects formulas were developed. For validation of these developed formulas case study was used. SC found to be approximately 5% of TPC with different weighing of recovery of cot (C1) = 0.29%, insurance cost (C4) = 2.6%, prevention cost (C15) = 1.5% and accident cost (C17) = 0.93%.

Organizational decision-making about safety and measuring success of an investment is encouraged by different calculation techniques such as cost-benefit analysis (CBA), payback period (PBP), return on investment (ROI), etc. (Lahiri et al., 2005). CBA gives arithmetic weighing of rewards and drawbacks which may affect an organization’s decision. CBA is an appealing ideology because of its linkage with significant assessment and conditional investigation (Tappura et al., 2015). By incorporating safety practices, such as first aid, PPE, safety training, etc., in projects, advantages such as low number of accidents, near misses, fatalities and injuries can be achieved (Brent, 2003). Safety benefits studied by different researchers using CBA and PBP are given in Table 4. It reveals that maximum payback for safety investment required is 2.5 years (Chhokar et al., 2005) and benefits of accident prevention are more than the cost of accident prevention (Amador-Rodezno, 2005; Elias Ikpe et al., 2012; Lahiri et al., 2005; Tang et al., 2004).

__Table 4: CBA and PBP of safety implementation__

Reference	CBA	PBP
Elias Ikpe et al. (2012)	3:01	
Verbeek et al. (2009)		Less than a year
Amador-Rodezno (2005)	5:03	
Chhokar et al. (2005)		2.5 years
Lahiri et al. (2005)	15:04	
Oxenburgh and Marlow (2005)		2 months
Tang et al. (2004)	2.27:1	
Lyon (1997)		1 year
Kemmlert (1996)		1-4 months

Ignorance of safety cost can be reduced by lighting the benefits which construction industry could achieve by investing for accident prevention. For this study was done on cost benefit analysis approach to find out the profit of accident prevention is more than the cost of accident prevention. (Elias Ikpe et al., 2012)

Categories of direct and indirect benefits of accident prevention is given by Hughes and Ferret (2007) shown in Table 5.

__Table 5: Direct & Indirect benefits of accident prevention__

Direct benefits	**Indirect benefits**
Saved insurance installment	Improved efficiency
Less cost of medical treatments	Reduced sick payment
Minimum lost time	Less working day lost
Less workers' compensation claim	Reduced damage resources
Paying less on litigation	Workers' satisfaction with work
Low cost of accident inquiry	Saving on hiring of tools and plants
Saving on safety training	Saving on image improvement
Less fatality	Increased workers 'confidence

Study by Masood and Choudhry (2012) highlighted that human factors are most essential element to reduce accidents and enhance safety situations providing proper knowledge, training, monitoring and controlling any dangerous condition. According to Elias Ikpe et al. (2012) construction parties are facilitated directly and indirectly and it is seen that direct advantages are more than indirect reward, demonstrating that any compensation result from preventive measures of safety facilitate construction members directly.

Chapter 3

Research Methodology

Research methodology of this paper comprises of five phases and is graphically presented in Figure 1. Following sections describe each phase in detail.

3.1 Phase 1: Conceptual Phase

Initially, recent studies on substantial areas of construction management were critically scrutinized. Safety management was found to be a challenging area in construction sector. After getting a starting point, basics of latest literature on safety were studied. It was found that despite the exhaustive work on safety, present condition of construction sector of developing countries in maintaining safe practices is not commendable. Previous studies present some work on safety culture and safety climate but there was a slight emphasis on its implementation. Considering this limitation, it was essential to discover the barriers and estimate SC which are impeding construction industry of developing countries for applying safety practices. By this, objectives were formulated which involve finding barriers to safety implementation, calculating cost of safety practices and its associated benefits. Based on the results of first two objectives, third objective was to devise strategies for safety implementation.

3.2 Phase 2: Theoretical Phase

In this phase, previous research was thoroughly studied to find out barriers and safety investment. Hence, papers were examined online on different libraries such as ScienceDirect, Scopus and Google Scholar with keywords of 'safety barriers', 'safety problems', 'safety difficulties', 'safety cost' and 'safety investment'. Substantial number of articles was retrieved and attention was given to those where these words were present especially in title, abstract and in keywords. Following this, extraneous papers were excluded and a total of 30 relevant papers, 15 on barriers and 15 on investment were found. Firstly, papers on safety barriers were carefully observed and 33 barriers were identified, as given in Table 1. In the next step, content analysis was performed to find significance of identified barriers. After this papers on safety investment were critically examined and 18 categories of safety cost were extracted, as shown in Table 2. Also cost against these categories was extracted, as synthesized in Table 3.

3.3 Phase 3: Data-Collection Phase

In this phase, a questionnaire survey was developed based on the identified barriers. It was distributed to industry professionals and academicians in several developing countries to solicit their opinion. The questionnaire contained 2 sections; the section 1 inquired about the demographical information of respondents and section 2 consisted of 33 multiple choice questions (MCQs) to inquire the importance of identified barriers on a 5-point Likert scale (1=Very low and 5=Very high). There was also one short question (SQ) to collect any additional information about safety practices. In order to develop a cost threshold, a questionnaire survey was developed and opinion on SC from highly experienced professionals from developing countries was gathered. This questionnaire contained 3 sections; demographic information of respondent; SQs about cost of safety preventions; and SQs about damages occurrence due to negligence of safe practices. After this, safety data was collected from actual projects regarding their safety performance, accident records and cost spent on safety measures. For this purpose, a series of interviews with project professionals was conducted. Due to the sensitive nature of this information and reluctant nature of professionals, safety data from only 15 real local projects could be gathered.

3.4 Phase 4: Analysis Phase

After collecting data through 1st questionnaire, reliability and normality checks were applied. Cronbach's alpha and Shapiro-Wilk tests were used respectively. For knowing the current trend of industry on the identified barriers, relative importance index (RII) was calculated using formula given in Equation 2 for each factor, where I = impact assigned to each barrier, n = sample size and H = highest impact which is 5 for current case.

$$RII = \sum In * H \qquad \textbf{\textit{Equation 2}}$$

Present trend of industry and academic experts on barriers was reported using RII and it was merged with the literature score (LS) to get total score (TS) for each factor using formula given in Equation 3. To calculate TS, 20% weighting was given to LS because it was obtained by subjective approach while 80% weighting was given to RII. Afterwards identified barriers were ordered using TS.

$$TS = (0.8 * RII) * (0.2 * LS) \qquad \textbf{\textit{Equation 3}}$$

Simultaneously, CBA was performed on real-time projects. In that, 2 scenarios were proposed and projects were divided accordingly. The scenario 1 (S1) had damages cost without safety measures while scenario 2 (S2) had damages cost with safety measures. Both of these scenarios were compared and benefit (B) was calculated using formula given in Equation 4, where N1 = damages cost of S1 and N2 = damages cost of S2. This exhibited that TSC was less if prevention cost (π) was applied and it also provide monetary and non-monetary benefits.

$$\mathrm{B} = \mathrm{N1} - \mathrm{N2} \qquad \textbf{\textit{Equation 4}}$$

After this B/C was calculated using Equation 5 by dividing benefits (B) by prevention cost (π) and according to Newnan et al. (2004) it must be greater than 1.

$$\frac{B}{C} = \frac{B}{\pi} > 1 \qquad \textbf{\textit{Equation 5}}$$

Following this, 2nd questionnaire was analyzed to calculate SC which should be kept according to the surveyed industry experts.

3.5 Phase 5: Results

In this phase, estimated cost for safety investment obtained from experts having more than 15 years of experience was used to remove the top most critical barriers obtained from TS. Then strategies for safety implementation were established using the remarks of experts obtained through survey.

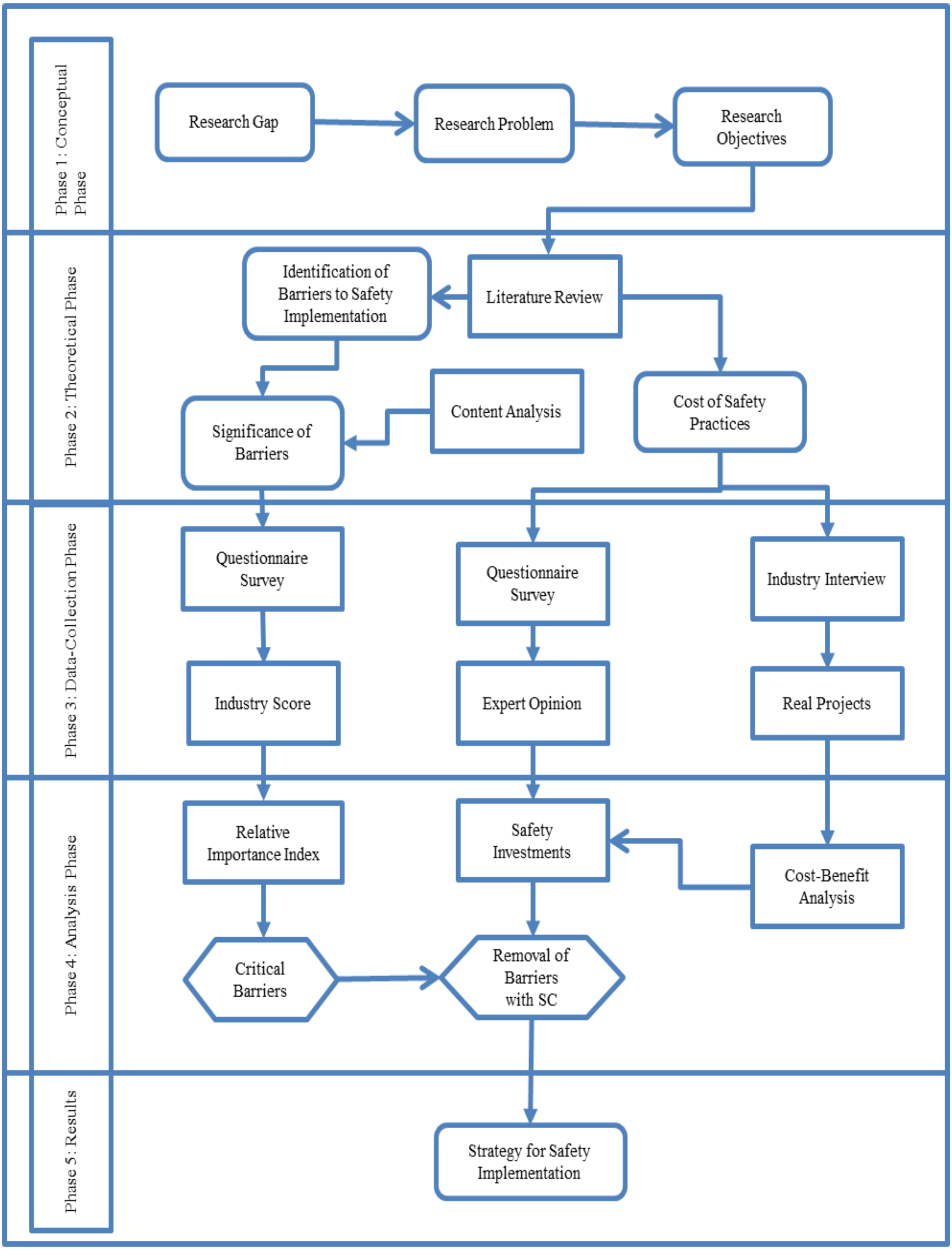

Figure 1: Graphical representation of research methodology

Chapter 4

Data Analysis, Results & Discussion

4.1 Survey responses

Respondents were approached using online sources such as official email as well as social, professional and research networks. The questionnaire was distributed to almost over 500 local and international field or academic specialist through LinkedInTM, ResearchGate® and Academia® and Facebook, after going through their profile, work and experience. Mostly civil engineers, safety experts, project managers, construction managers and professors were targeted. A total of 162 responses were collected, out of which 10 were found incomplete, thus 152 responses were used for further analysis. Their regional distribution is presented in Figure 2, showing that respondents belonged to various countries including Pakistan, Qatar, Ethiopia, Indonesia, Hungary, Croatia, Iraq, India, Jordan, Bahrain, Saudi Arabia, Egypt, Syria, Mexico, Oman, Kuwait, Malaysia and Algeria.

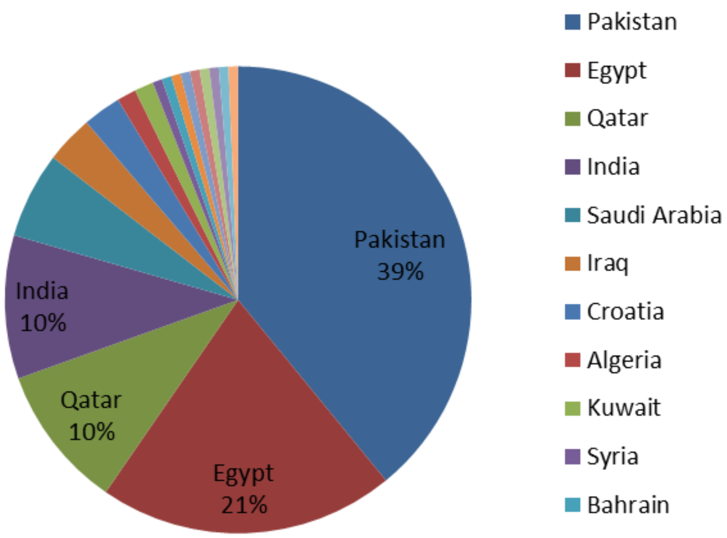

Figure 2: Regional distribution of responses

Data was composed of diverse set of responses having differing qualifications and level of experience as given in Table 6. It can be observed that 71% respondents had experience from 1 to 10 years and the majority had a BS or MS qualification. The remaining respondents were well qualified with doctoral or post-doctoral education and had more than 10 years of experience. Likewise nature of their job is also synthesized in Table 5. Survey covers academicians, researchers and industry experts.

Table 6: Respondent's information

Work Experience	0-5	6-10	11-15	16-20	>20
Responses	54.6%	16.6%	12.3%	7.4%	9.2%
Qualification	B.Tech	B.Sc/B.Eng.	M.Sc/MS	PhD	
Responses	6.1%	42.3%	40.5%	11%	
Nature of Work	Assistant Executive Engineer, GM, Principal Engineer, Director, Assistant Professor, Professor & HoD, Senior health, safety and environment (HSE) Officer, Strategic and Planning Manager, Contracts Specialist & Risk Manager, Project Manager, and Construction Manager				

4.2 Statistical analyses

In order to check the reliability of collected data for further analysis, Cronbach's alpha test was used. Reliability of data is based on α-value and it must be greater than 0.7 (Chow and Chan, 2008) and value above 0.9 depicts that data is very consistent. The α-value for current data was 0.905 showing that it is highly reliable and consistent for further analysis. Afterward, Shapiro-Wilk test was applied to check the normality of data. This test is used for sample size ranging from 10-2000 and appropriate for all types of distributions. Normality of data is based on p-value which must be greater than 0.05; it also shows that data is parametric (Razali and Wah, 2011). After performing the test, p-value for current data was zero which indicates that data is not normally distributed and is non-parametric. Finally, Kruskal-Wallis H test was performed on non-parametric data to check the similarity and difference in perception of respondents from different regions. Values for majority of barriers were significant showing that respondents have similar views. The perception was different only for two barriers which are limited safety resources and less legal binding towards safety. As survey was focused on developing countries so they had different views about resources and legal binding. Some countries are doing well in safety and have some safety rules and binding. Due to heavy fines as said by an interviewee companies in some countries are strict towards safety while other are not where there is no fare of fine which can be seen here.

4.3 Relative importance index

In order to assess the significance of identified factors, RII was calculated as explained in methodology section. Also, the identified barriers are classified into different categories based on their nature. Previous published work is critically scrutinized to ensure such categorization process. This categorization along with individual RII is given in Table 6.

Table 7: Categorical distribution and ranking by RII

Knowledge & Awareness		B10	15
B13	1	B25	20
B26	4	B16	22
B6	6	B17	27
B29	8	B19	28
B9	17	**Legal & Procurement method**	
B30	18	B23	3
B20	19	B14	7
B12	24	B8	11
B1	29	B4	16
Financial support		B21	19
B3	2	B27	21
B2	5	B7	23
B28	10	B15	26
B5	14	**Others**	
Management role		B31	23
B24	9	B11	30
B18	12	B32	31
B22	13	B33	33

All identified barriers fall under four defined categories but only four barriers do not directly fit into the categorical distribution, therefore they are placed in ‘others’ category. Barriers are almost evenly distributed among three categories except for the ‘financial support’ category. These three categories are versatile owing mixed ranking of barriers placed inside them.

Most important category in this regard is ‘financial support’ because majority of the significant barriers fall in it. Safety investment (B3) is the 2nd most major barrier among all. It is defined as the cost used to emphasize safety control in form of training, incentives, staffing and PPE (Feng, 2013). These resources are used to lower down the rate of injuries, rather than just adding cost. Other barriers in this category, which are interrelated to safety investment (B3), are limited safety resources (B2), high cost of training and implementation (B28) and additional cost to design for safety (B5) occupying 5th, 10th and 14th ranks respectively. This dependency suggests that investing money on safety measures helps in elimination of other barriers that fall in the same category.

Other important category is ‘knowledge and awareness’ due to presence of most and least significant barriers in it. First one in this category is ineffective training of safety personnel (B13) which is a highly ranked barrier. Mushayi et al. (2017) highlighted that positive safety culture could be realized through health and safety training. It can improve worker’s attitude, behavior and the way they perform which ultimately improve an organization’s reputation. The second most important barrier under this category is inappropriate knowledge of PPE (B26). Proper education about safety management can create a safe and healthy working environment (Le et al., 2015). As Raheem and Hinze (2012) found that instead of an increasing number of PPE on construction sites, no improvement was seen in accidents rate because workers were illiterate about usage of PPE. Next major barriers are verbal and mental inability of workers (B6) and incompetency of safety knowledge (B29). These are also among the top ten critical barriers while least significant factors such as less formal training of stakeholders (B20) and language and educational barriers (B1) are also present in this category. It can be seen that barriers under this category are interconnected and can easily be resolved by taking action on the top critical barriers.

Next is the ‘legal and procurement method’ category which involves critical barriers such as less attention to safety in standard contract (B23) and less legal binding towards safety (B14) having 3rd and 7th overall ranks. Raheem and Issa (2016b) suggested that the most important regulatory amendment is improvement in standard contract by engineering councils, and regulatory and administrative bodies. Moreover, due to the absence of labour laws enforcement, numerous accidents on construction sites are not conveyed to labour department except for those which results in mortalities or gain media attention (Raheem and Hinze, 2012). Major project stakeholders should pay sufficient attention to contractual conditions so that barriers like nature of construction contracts (B4), legal and liability issues (B7), weak or absent regulatory requirements (B8), conflicts with contract conditions (B15), need of officially authorized infrastructure (B21) and unclear language of bidding document (B27) can be removed by improving the procurement method.

The next category is ‘management role’ in which one of fundamental barriers is less detail of record keeping (B24) which is at 9th position overall. Major reason hindering safety implementation is unavailability of safety data making it difficult to procure a contractor on their safety performance (Raheem and Issa, 2016b). According to Zahoor et al. (2016), a database must be developed to record number of accidents and fatalities against completed and on-going projects. Previous records also help in hazard identification and accidents investigation, thus improving safety performance. There is a dire need to change company’s safety culture by which barriers like culture of risk transfer (B10), tradition for new improvement scheme (B19) and methods to integrate safety into company’s culture (B22) could be mitigated.

Lastly, barriers with low rankings are placed in 'others' classification. Migrant workforce (B11), worker's dissatisfaction with safety training (B31), work on piecework costs (B32) and lack of union representation (B33) fall in this category. These are barriers that will be removed if the top ranked barriers should be given sufficient importance. Worker's dissatisfaction with training (B31) includes many factors such as language barrier especially for migrant workforce (B11). Lack of understanding of safety training leads to many work injuries. Formal training should be given to workers to enhance their understanding on safety knowledge and procedures (Motiboi and Abdullah, 2017). Keeping in view the above discussion, it is found that the barriers are closely associated with each other, presenting a complex web of connections. Therefore, addressing the top ranked barriers will help in eliminating the bottom level barriers. This will ensure a minimalist intervention which can offer a large and long-term return against a small and short-term investment.

Thus, it is essential to remove the barriers in order to implement safety and the necessary investment is inevitable in this regard. To operationalize this aspect, data related to safety cost was collected through a discussion-based survey (Hellström and Husted, 2004; Punagin and Arya, 2015). A total of 18 industry professionals having over 15 years of experience in the related field were engaged. They were asked to provide percentage of cost with respect to TPC against each SC category of prevention (π) and damages (Δ) costs given in Equation 6.

$$SC = \pi + \Delta \qquad \textbf{\textit{Equation 6}}$$

The prevention cost (π) is used to eliminate the maximum possible barriers. In doing so, it is the money spent to ensure safety and includes administrative personnel (ω) and safety measures (σ) costs given in Equation 7.

$$\pi = \omega + \sigma \qquad \textbf{\textit{Equation 7}}$$

The administrative personnel include onsite and head office safety professionals who ensure a better safety culture and help organizations to achieve their safety goals. Barriers like culture of risk transfer (B10), difficulty in providing safety management (B16), adding new scope to the project (B17), increasing the speed of construction activity (B18), traditions for new improvement scheme (B19), methods to integrate safety into company's culture (B22) and coordination between SO and PM (B25) could be mitigated by investing into safety professionals. A company has to pay less to transfer its risks to third party as presence of SO and PM guarantee an improved and safe environment thus enhancing safety management. Abudayyeh et al. (2006) studied the correlation between safety management and frequency of injuries and fatalities on construction site. It was found that cost resulting from unsafe practices such as schedule disruption, insurance and compensation expense could be minimized by focused efforts of safety managers. Toole (2005) discovered the impact of PM on level of safety in construction sector and suggested that PM and SO should consider the company policies, safe practices, worker attitude and safety knowledge to improve performance and reduce accident rate. So, collective efforts are essential to improve overall culture.

On similar lines, traditions for new improvement scheme (B19) in safety can be supported by administrative authorities (Zwetsloot et al., 2017). Modern techniques for betterment may include technological advancements. According to a study by Zahoor et al. (2016), reason for poor safety performance of construction industries is more dependency on labor force rather than latest equipment and technical development. Thus, a link between safety management and advance technology was found by Zhang et al. (2015). A model was developed which helps SO and PM to plan for safety efficiently and assist in decision-making which showed that involvement of management is crucial in safety. So, administrative personnel cost (ω) was acquired through questionnaire in which 16 out of 18 respondents gave its percentage with respect to TPC and responses were averaged to get percentage cost. It is found that spending 0.575% of TPC on administrative personnel may remove the barriers related to management in safety performance.

Furthermore, cost of safety measures (σ) includes costs of PPE, first aid, education and training, investigation, promotion and incentive, and cost of new technologies and methods. Further, it is used to eradicate various barriers such as language and educational barrier (B1), verbal and mental inability of workers (B6), mindset of workers of SMEs (B9), ineffective training of safety personnel (B13), less formal training of stakeholders (B20), inappropriate knowledge of wearing PPE (B26), high cost of training and implementation (B28), incompetency of safety knowledge (B29) and less awareness of construction work (30). These barriers could be eliminated by proper training and knowledge which demand a little investment with great return. Hamid et al. (2008) highlighted the main reasons for poor safety and increased number of accidents that include inappropriate knowledge, failure to follow safety procedures, limited knowledge of PPE, operating equipment carelessly, poor management at site and workers' attitude towards safety.

Lin et al. (2011) showed that education is essential for encouraging a safe and healthy atmosphere and it is found to be a serious agenda among construction sector. Against an accident rate of 70% for labour who did not receive safety education and training. Ho and Dzeng (2010) demonstrated the importance and effectiveness of such education which helps in promoting safety, saving human resources and maintaining economic development. So, involvement of human resources could overcome deficiencies in safety education and training (Gambatese et al., 2005a). Safety training starts with education of hazard identification. As Sacks et al. (2013) showed that workers could easily asses risks and hazards through training and eventually help in reducing the number of accidents and fatalities. A safety training program was developed by Kartam et al. (2000) and applied to 100 construction companies which show a clear difference in workers' performance and number of accidents. Workers exhibit better compliance with health and safety rules by resilient safety training programs (Wilkins, 2011). Another intervention program was developed to train contractor, safety supervisor and top management for assuring improved safety for workers with successful outcomes (Roelofs et al., 2011).

Loosemore and Andonakis (2007) suggested some remedies for betterment of safety performance which include a healthier communication between safety professionals, active involvement of all workers and top management in safety education programs; and training through advanced technology and supporting cost of training which ultimately result in reduction of injury rate (Hallowell, 2010). Safety knowledge of supervisor and contractor to improve management skills and understanding their workers could enhance safety climate and reduce maximum hazards. Language training for migrant workers is necessary for sound atmosphere (Roelofs et al., 2011). Advance technology helps in providing training and removing educational and language barriers by visualization such as virtual reality, 3D gaming and building information modeling are successful and effective interventions in terms of workers' learning, and identifying and assessing hazards (Sacks et al., 2013). So, keeping in view the importance of cost of safety measures (σ) it was calculated through questionnaire in which 17 out of 18 respondents gave its percentage with respect to TPC. It is found that an average of 2.257% of TPC is required to provide better and sound safety environment.

Overall prevention cost (π) is calculated using Equation 6 which comes out to be 2.85%. This investment can help in creating strong safety culture, good reputation for the organization, reduced number of accidents, and less compensation and insurance cost.

Further, damages cost (Δ) is the money spent after occurrence of accident. It comprises of direct (δ), indirect (ι), work-time (θ) and schedule (ς) costs as presented in Equation 8.

$$\Delta = \delta + \iota + \theta + \varsigma \qquad \textbf{\textit{Equation 8}}$$

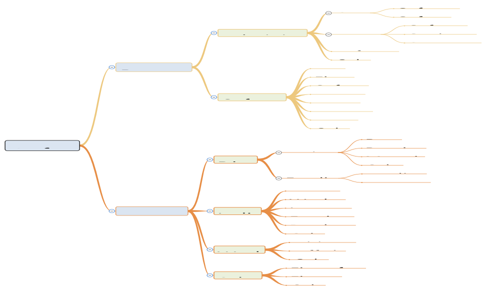

Figure 3: Categories of SC

Safety damages cost (Δ) was calculated through the questionnaire in which 17 respondents gave percentage for direct (δ) and indirect (ι) costs while 15 gave percentage against work-time (θ) and schedule (ς) costs. By averaging, percentages were calculated in which contribution of direct cost (δ) was 1.175%, indirect cost (ι) was 0.468%, work-time cost (θ) was 0.28% and schedule cost (ς) was 0.85%. Total cost for damages was found to be 2.77%. It shows that prevention (π) and damages (Δ) costs are almost equal and TSC is obtained by summation of above mentioned costs which is 5.62%. Averaging TSC as asked in questionnaire comes out to be 6% with minimum percentage given was 0.052% and maximum was 15%. A model for breakdown of TSC is prepared on MindGenius software given in Figure 3. It consists of main categories which are further classified into sub-categories.

To encourage safety investment, CBA was performed on data from real projects. In this regard, a number of interviews were conducted with construction professionals to extract information related to safety practices and investment. A total of 15 projects were studied under two scenarios (S1 and S2) as explained in detail in the methodology section. A trend was observed between projects of each scenario shown in Figures 4 and 5.

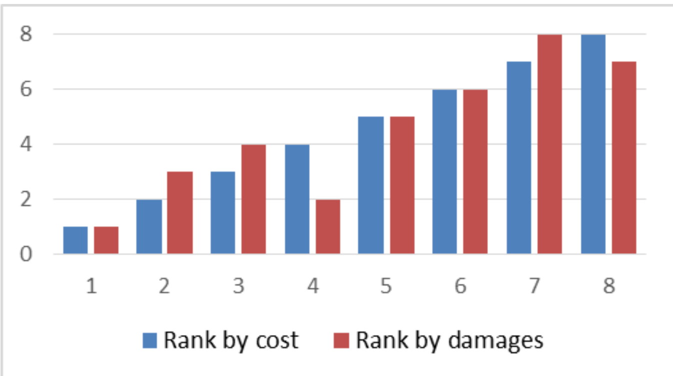

Figure 4: Projects without prevention cost (π)

It is evident from Figure 4 that as cost of projects increases, their damages cost (Δ) also goes up. Same can be seen in Figure 5 as project cost increases, prevention cost (π) also increases thus decreasing the damages cost (Δ).

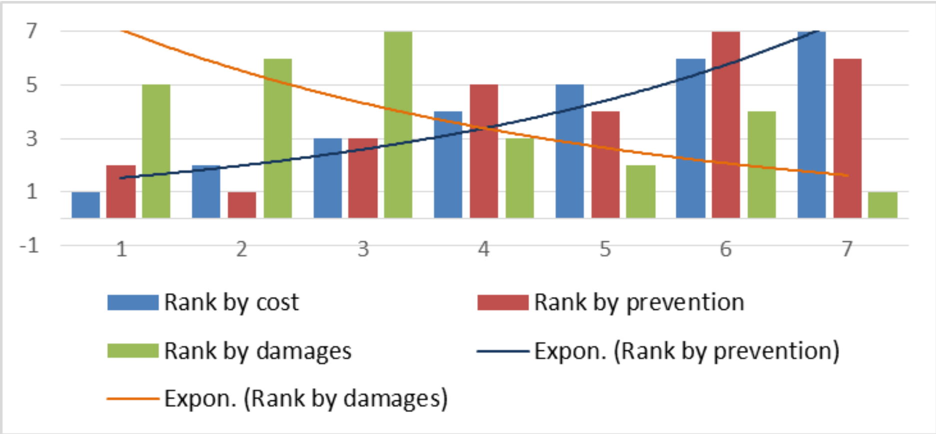

Figure 5: Projects with prevention cost (π)

To take insight into the cost and benefits of projects, the collected data was converted to ratio analysis since the construction works include projects of differing worth and consume different amount for safety cost to attain numerous benefits from these investments. The collected costs were converted to the same scale of 10 million for further computation. Consequently, this research incorporated the benefit/cost ratio (BCR) method to uniformly compare the benefits and costs of construction projects. This similar type of work has been adopted in previous studies (Elias Ikpe et al., 2012; Ikpe et al., 2008; Tang et al., 2004).

Furthermore, Rossi et al. (2005) studied that benefits could be calculated by net cost comparison method. The benefits were calculated for both presented scenarios using Equation 4 explained in the methodology section and came out to be 1.07 million for 10 million. Average of damages cost (Δ) for S1 was 11.6 million against a TPC of 826 million while the same was 98 thousand against a TPC of 1.9 billion for S2. It clearly shows that projects with no prevention cost (π) were suffering with a high amount of damages cost (Δ) therefore safety investment would be beneficial as per the findings. The TSC and benefits were compared across different projects data using Equation 5. After computing benefits by prevention cost BCR was 1.21 > 1 which means that safety investments are highly encouraged as Newnan et al. (2004) stated that benefit ratio should be greater than 1 for any investment to be successful.

4.4 Strategies for safety implantation

After finding critical barriers and cost of safety investment, there was a need to develop strategies that may help in removal of barriers and successful safety implementation. The professionals were approached for this purpose who suggested different tactics for improvement and application of safety. Their opinions were carefully analyzed, transliterated and compiled. The following strategies, graphically presented in Figure 6 along with the corresponding barriers, were formulated through expert opinion.

- Regulatory bodies are essential for development of safety policies and they should periodically check companies' performance to ensure safety practices. Such bodies should ensure compliance of highest order and there should be a proper mechanism to control and monitor safety. With their help barrier of weak or absent regulatory requirements (B5) can be resolved. As Raheem and Issa (2016a) developed a safety regulatory framework for construction sector giving rules and procedures for successful safety regulatory organization.

- Due to less binding, strictness and attention on safety implementation results are unpromising. This state of despair originates right from the contractual arrangement where not much mention of safety implementation was found. Behm (2005) suggested that safety in construction contracts can start design for construction safety. This startegy help in removing barriers like less attention to safety in standard contract (B6), less legal binding towards safety (B7) and nature of construction contracts

(B10). Hinze (2000) showed that legal and contractual barriers prevent architects from applying safety during design as a standard pratice. Therefore, safety implementation should be considered equal to design measures in projects and contractors should be hired based on their safety performance. All of it must be regularized through proper contractual provisions.

- Safety investment is considered important for safety implementation. Barriers like ineffective safety training (B1), safety investment (B2), limited safety resources (B3) and educational barriers (B4) can be eliminated using this strategy. It helps in providing education and awareness (Lingard, 2013; Hon et al., 2012). Regular training programs should be encouraged that will provide knowledge among organizations. López-Alonso et al. (2013a) studied the effectiveness of safety investment and showed the associated benefits for any organization. So, HSE cost should be included in cost baseline and must be regularized as a bill of quantities (BOQ) item. Contractor and client should be made responsible for payment of HSE costs.
- Management plays a key role in improving safety environment by making policies, adding it into everyday topics and supporting its implementation by hiring safety professionals (Hasle et al., 2010). Management can help in resolving verbal and mental inability and worker's behavior (B11) and culture of risk transfer (B13). Special programs should be planned for awareness of safety which can positively influence a firm's decisions (Feng et al., 2014). Necessary safety literature such as pamphlets and booklets along with equipment must be present on site. There must be weekly safety lectures, monthly safety training classes and daily safety meetings before the start of the day. This can minimize the hazards and increase awareness

among labor. Safety is a lifestyle; if communicated properly down the line, it becomes a habit. Management commitment towards safety should be consistent.

Figure 6: Strategies for safety implementation

Chapter 5

Conclusions and Recommendations

Safety management is a serious problem for construction sector in the developing countries (Zhou et al., 2015). It is challenging to divert attention of construction professionals from profits to human resources which do not receive their due importance. There is a need for a proper system to provide knowledge and awareness and then transmitting this knowledge into action to achieve anticipated outcomes (Ho and Dzeng, 2010; Lin et al., 2011). Safety implementation is considered very important in order to improve state of affairs in the construction sector and it requires efforts at all levels. Observing construction sector of developing countries, where poor safety conditions are prevalent, present research is expected to help in improving the state and applying safety practices in better way.

For this purpose, 33 barriers were retrieved from previous studies and ranked through literature score. Further, their significance was calculated after observing trends of different developing countries. List of top barriers was prepared after combining their industry and literature scores. Afterward, cost spent on safety practices was calculated so that maximum possible barriers could be removed which shows a clear link between safety barriers and investment. SC was divided into major categories which were further divided into subcategories and percentage was calculated for each and every category. CBA was then performed showing its tangible and intangible benefits with an intent to advocate its effectiveness and motivate the construction sector towards safety implementation. Based on this, strategies were developed that can help in successful implementation of safety. Strategies include presence of regulatory body, involvement of management, consideration towards procurement method and encouragement of safety investment. In the form of current study, the body of practice is provided with a comprehensive assessment and decisive results on the effectiveness of investing on safety in the form of a positive trade-off between cost and benefits.

It is recommended to formulate in contracts 5.62% of TPC as safety cost out of which 2.85% is used for safe practices and remaining 2.77% would be used in case of any hazardous condition occur during project. It is also recommended to replicate the same perform Current study was done on local projects having voluntarily safety practices. Results could be more appealing if same study would be replicated in a context which has good safety practices.

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ANNEXURE-I

Barriers to safety implementation: A cost-benefit analysis

Respected Sir/Madam,

This survey is being carried out as part of MS research titled "Barriers to safety implementation: A cost-benefit analysis". The purpose of this research is to propose a strategy by which safety practices within construction industry could be implemented and their investment could be encouraged by keeping in view their benefits. For this, problems must be identified which are hindering safety implementation. This elementary survey will help to identify the most important factors that discourage proper implementation of safety in construction projects.

Your contribution towards this research will be highly appreciated. Please be assured that the data will only be used for study purpose and no personal information will be disclosed at any forum/level. Please click next to continue and complete the survey and remember to click submit at the end. In case of any inquiry, please feel free to contact.

Regards, Shamraiza Khan

Post Graduate Student,

Dept. of Construction Engineering & Management,

National Institute of Transportation,

School of Civil & Environmental Engineering,

National University of Sciences & Technology (NUST),

Islamabad, Pakistan

Email: shamraiza.cem7@nit.nust.edu.pk

Email address: ______________________

1. **Demographic Information:**

    i. Organization/Institute: ______________

    ii. Job Title/Position in Organization: ______________

    iii. Highest academic qualification

B.Tech	B.Sc/B.Engg	M.Sc/M.S	PhD/D.Engg

    iv. Total Work Experience

From 0 to 5	From 6 to 10	From 11 to 15	From 16 to 20	From 21 and above

    v. Country: ______________

2. **Barriers to Safety Implementation**

To what extent the following barriers hinder the application of safety in construction sector.

Numbers	**Equivalent to**
1	Very low
2	Low
3	Medium
4	High
5	Very High

Mark only one option per row

	1	2	3	4	5
Ineffective safety training					
Safety investment					
Limited safety resources					
Educational barriers					
Weak or absent regulatory requirements					
Less attention to safety in standard contract					
Less legal binding towards safety					
Inappropriate knowledge of PPEs					
Additional cost of designer to design for safety					
Nature of construction contracts					
Verbal and mental inability and worker's behavior					
Incompetency of safety knowledge					

Culture of risk transfer					
Less detail of record keeping					
High cost of training and safety implementation					
Mindset of workers of small and medium enterprises (SMEs)					
Increasing the speed of design or construction activity					
Methods to integrate safety into company’s culture					
Traditions and skills for new improvement scheme					
Less awareness of construction work					
Legal and liability issues					
Less awareness about role of stakeholders					
Less formal training of stakeholders					
Need of officially authorized infrastructure					
Coordination between project manager and safety officer					
Unclear language of bidding document					
Difficulty in performing safety management					
Conflicts with contract conditions					
Worker’s dissatisfaction with safety training					
Migrant workforce					
Adding new scope to the project					
Work on piecework costs					
Lack of union representation					

ANNEXURE-II

Cost of Safety before and during Projects

Respected Sir/Madam,

This survey is being carried out as part of MS research titled "Barriers to safety implementation: A cost-benefit analysis". The purpose of this research is to propose a strategy by which safety practices within construction industry could be implemented and their investment could be encouraged by keeping in view their benefits. For this, cost of safety which is kept before starting a project and cost that incurred during execution of project must be needed. So, that total cost of safety could be calculated.

Your contribution towards this research will be highly appreciated. Please be assured that the data will only be used for study purpose and no personal information will be disclosed at any forum/level. Please click next to continue and complete the survey and remember to click submit at the end. In case of any inquiry, please feel free to contact.

Regards, Shamraiza Khan

Post Graduate Student,

Dept. of Construction Engineering & Management,

National Institute of Transportation,

School of Civil & Environmental Engineering,

National University of Sciences & Technology (NUST),

Islamabad, Pakistan

Email: shamraiza.cem7@nit.nust.edu.pk

1. **Demographic Information:**

i. Experience of Respondent (Years): ________________

ii. Total safety cost (% of project cost): ________________

iii. Country: ________________

2. **Safety investment on projects**

i. Cost of administrative personnel

Please give percentages with reference to total project budget

Cost of Administrative personnel Onsite	**Cost (%)**
• Safety supervisor	
• Safety officer Secretary/typist/clerk	
• Others	
Cost of Administrative personnel office module	
• Safety manager	
• Chief safety officer	
• Senior safety officer	
• Secretary/typist/clerk	
• Others	

Cost information about safety control

Cost of PPE's	**Cost (%)**
• Hard hats	
• Safety goggles	
• Safety jacket	
• Safety harness	
• Safety gloves	
• Safety boots	
• Safety lanyard	
• Respiratory protection	
• Other (If used specify)	
Educational costs/Safety training cost	
Costs for investigation, documentation and certification of HSE-MS	
Costs of promotion and incentives	
Cost of new technologies, methods or design tools	
Committee costs	
Other cost (Specify if any)	

Cost arising because of accident/injury or fatality

Direct costs	**Cost (%)**
Damage of equipment's and machinery costs	
Repair of damaged equipment's (e.g. repairable machineries)	
Renting or purchasing of tools, equipment's, layouts and services	
Costs of materials damage (raw material)	
Medical costs	**Cost (%)**
Cost of treatment using first aids (For which the doctor's presence in not required)	
Medical expenses (Includes injured persons who need to be in the hospital, doctor's fees and the cost of hospital, in general, those which require the doctor's presence)	
The costs of hiring workers to replace the injured one (Hiring cost include interview, training cost for new employee)	
Insurance cost	
Other cost (Specify if any)	

Indirect costs	**Cost (%)**
Capacity lost costs	
Work stoppage cost due to accident (lost production time)	
Employee's overtime cost (Employee's overtime to compensate the damage and the stoppage of the production)	
Productive time lost by employees and supervisor because of accident	
Other cost (Specify if any)	

Schedule costs	**Cost (%)**
Fines for canceled order that company could not deliver due to the accident	
Fines due to delays in deliveries	
Other cost (Specify if any)	

Work time costs	**Cost (%)**
Costs of accident analysis and investigation	
Cost of time invested to replace injured worker	
Payment cost Salary of injured worker while off work (while worker is on the medical treatment)	
Cost of representative and legal cost	
Cost of new changing (management, organizational and services) for prevention of similar accident	
Other cost (Specify if any)	