INVESTIGATION FOR SAFETY PERFORMANCE INDICATORS ON CONSTRUCTION PROJECTS

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ABSTRACT: *Implementation of injury/fatality rates in construction is questionable due to absence of administrative body for safety and health in Pakistan but research studies showed significant increase. Accidents records investigation provides lagging indicator of safety performance which is not truly adopted by construction firms. Alternatively, safety climate is leading indicator which addressed safety perceptions and attitudes of workers for safety management system. This study is an effort to develop relationship between lagging and leading safety indicators. Accidents were ranked according to vulnerability and then associated safety climate was investigated. Major reason of accident was found as defective equipment endorsed in psychological perspective including site ergonomics and, plant and equipment along with productivity as priority over safety. There is clear weak relation between lagging and leading indicators of safety performance as most accidents are happening due to tools but workers perceive that proper PPE is provided and no tools are defective as workers have no training to use equipment. In light of current study, it is recommended that construction firms should provide flawless tools and equipment along with justified workload to avoid hazardous situation on construction projects.*

KEY WORDS: Accident, Safety Climate, Workers, Safety performance, Construction, Pakistan

1. INTRODUCTION

Construction is ranked third among the most hazardous industries in Pakistan with high injuries, occupational diseases [1] and fatality rates (both reported and unreported). Earlier research showed poor safety culture [2] with inadequate safety management system[3,[4], safety climate with weak perceptions [5], uncertainty avoidance attitude and non-practice behavior [6] in situation with saturation of many safety rules and regulations with less application caused negligence towards labour laws in context of safety [7,8]. Workers operating in a more collectivistic, leftist, and better uncertainty avoidance environment, have more possibility to have safety awareness and beliefs and therefore exhibit safer work behavior [9]. Current study is focused to relate safety management and perception based performance indicators to investigate the common accidents/injuries and perceptions of employees.

Construction safety is the action of keeping safe and safety is a contrivance to prevent injury or avert danger, and attributed as a mechanism to prevent the occurrence of an accident. [10] stated that statistics related to accidents are insensitive, and cannot be a reliable indicator of safety. One major drawback of traditional safety measures is that they are retrospective, noting down the unsafe behavior after it has occurred [11,12]. It is a common understanding that unsafe behavior is by default linked to workplace accidents. The safety climate inside construction site environments has a positive correlation with workers' safe behavior. The attitude of Construction Workers regarding safety is influenced by their apprehensions of risk, safety rules, procedures and management. Addressing measures for safety e.g., the rates of accidents and costs of compensation often mean that the "success of safety is indicated by the levels of system failure" [13]. Recently, there has been a deviation from safety measures purely based on retrospective data or ''lagging indicators,'' such as accident rates, toward so-called ''leading indicators'' such as site investigation and measurements of safety climate [14]. Leading indicators are upstream, predictive, heading and positive but lagging indicators are downstream, historical, trailing and negative.

Lagging indicators are measurements that are linked to the consequences of an accident such as injuries and fatalities. Accidents on construction sites happen either because of absence of knowledge or training, limited supervision, or a lack of methods to carry out the task in a safe manner, or alternatively, because of an error of judgment, apathy or carelessness [15,16]. Injuries can be categorized into many types, like first aid injuries; medical injuries (no lost work shifts); disabling injuries (where at least one shift is lost) which can either be permanent or temporary in nature; and fatal injuries.

Studies prove that the implementation of major safety practices opting for a sound safety program can control accidents and prevent hazards [17,18]. Only Physical injuries and fatal injuries are mostly taken significant by the employers. The reason is direct costs associated with them. But the fact is that all accidents do not end up in injuries or damage to the equipment or material. In reality, the accidents that do not result in damage are the ones which are valuable and hold important answers for the future safety concerns [19].

Safety climate can influence safety performance [20] and it is the most valid leading indicator definition that *safety climate reflects employees' perceptions about the organizations' safety management system including policies, practices, and procedures that show how safety is implemented in construction sites environments*. The

influence of safety climate on safety behavior of individuals boils down into safety performance, termed as effective way [21] and this safety performance can be effectively improved through safety training [22]**.** There is consensus among researchers that safety climate is vital measuring construct (psychological) of safety culture and named in various ways as product [23]; manifestation [24]; indicator [25]; abstraction [26]; and snaphot [21]. Measuring the safety climate of an organization is like taking the ‘‘safety temperature” [27]. Research studies provided evidence of correlation through identified dimensions or factors, a measure of safety climate with safety performance,28].

2. LITERATURE REVIEW

The benefit of leading performance indicators (Safety climate) is that they identify the fragility in safety management practices before they transform into accidents i.e. lagging indicators [26]. Giving priority and value to safety (i.e., having a positive safety climate) has been proved to increase safety performance and decrease injuries [29]. Recent advanced analysis has confirmed that safety climate is linked with enhanced safety performance and decreased accident rate [30]. Safety climate can be taken as an alternative safety indicator[31]. Actually the power of the safety concept lies in its ability to predict safety performance [32].

Leading indicators of safety performance are characterized as consisting of a set of selected measures that describe the level of effectiveness of the safety process[19]. Leading indicators measure the building blocks of the safety culture of a project or company. When one or more of these measures suggests that any aspect of safety process is weak or weakening, intervention can be implemented to improve the safety process and thereby positively impact the safety process before any negative occurrences (injuries) are sustained.

The relationship of safety climate analysis with other positive performance (leading) indicators of occupational health and safety which can be classified as passive in context of a firm or a project (management personnel, field employees, subcontractor election, subcontractor site safety program, subcontractor commitment for worker safety) and active subject to short term change (toolbox meeting, pre-task planning, drug test, number of close calls, safety audits, owner promotion, worker observation record[33].

With lagging indicators, the need for change in the safety program cannot be realized until at least one injury has been sustained whereas leading indicators are viable and promising alternative to be considered but [34] past performance is a poor predictor of future results. Additionally, an unbalanced focus on lagging after-the fact based measures may convey an unintended message that safety prevention is less important. Knowledge of accidents in terms of injuries and fatalities helps to identify the key perception (safety climate) aspects which need to align for improving safety culture on construction site.

3. MATERIAL AND METHOD

Hypothesis and Limitation of Research: There is strong relationship between lagging and leading safety performance indicators. This study investigated safety climate for reduction in prevailing accidents which resulted injuries and fatalities. Current study addressed safety performance on construction projects located in Pakistan.

Review for Accident records: Three research studies was considered and reviewed for evaluating common construction accidents according to vulnerability ranking happened in Pakistan.

Questionnaire Survey for Safety Climate: A safety climate questionnaire was adopted previously used for study from [5] with statements related to construction accidents. The questionnaire was based on a five-point Likert - type scale (from 1 = “strongly disagree” to 5 = “strongly agree”). Mean safety climate score (MCSC) was used by [6] which represents average value upon Likert scare against all safety items, and further evaluates weak or strong perception regarding safety. Mean score of safety climate statements (related to construction hazardous, incidents and accidents) was calculated.

Data Collection

In Pakistan, average increase in construction related injuries and diseases were observed according to relative percentage 12.54 (2002) to 13.10 (2011), hence construction industry is ranked 3rd in the most hazrdous industries of the country [1]. Most companies have an average fatality rate per project in the range of 2-5% of the total project work force [35]. Construction sites normally record the accidents occurring during execution of project activities [4] but accident reporting and recording system is dysfunctional [36]. Procedures for accidentreporting and investigation, mechanisms for implementation of safety work rules, processes for safetyrecord keeping and logging, methods for accident response, and practices for safety performanc eevaluation are not suitably applied by majority of the contractors. However, – more because of a practice– jobsite safety inspections, site layout planning and provision of first aid facilities on site are relativelystronger implementation areas of safety [2] .

Table 1: Ranking of Types of injuries in chrolonological studies.

Type of Injury	Research Studies		
	YR 2006 [37]	YR 2007[2]	YR 2011 [38]
Fall injuries	2	1	2
Struck-by injuries	1	2	3
Injuries by wastage and raw materials	1	3	-
Heat Stroke	4	4	1
Head Injuries	4	5	1
Eye injuries	3	6	1
Burning cases	4	7	1

Safety Climate Survey was conducted on twenty three constructions sites of diversified types as infrastructure, high rise buildings, facility buildings, roads and bridges. 76% of response have been received from sixty one workers of different trades (for work, steel fixing, concreting, plaster, scaffolding and related helpers).

Data Analysis

Following research studies were carried out to investigate construction accident trends in Pakistan:

- Major causes of injuries are cave-in due to less shoring during excavation; falling from scaffolding while working on high levels; damage to eye while cutting wood or steel; lack of care and maintenance to tools as welding plants, electronic equipment, and temporarily laid power lines [37]
- As per the survey results, the main types of injuries recorded by contractor companies on the construction sites, are given in descending order of occurance as follows (the percentages in parenthesis indicate the weighted average percentages of the injuries based on a combined proportion of percentage of occurrence of the injury and percentage of companies facing the injury): Fall injuries (55%), Struck-by injuries (53%), Injuries by wastage and raw materials (36%), Heat stroke (33%), Head injuries (25%), Eye injuries (21%), Burning cases (9%). Falling from height has been found as one of the major causes ofconstruction fatality. From company safety records, it was found that falling from roofs and floor openings was the major cause of such injuries. In order to prevent such injuries and fatalities,contractors reported use of safety belts, ropes and cables. Safety nets were also reported to beused by few contractors. However, looking at the high value of weighted percentage of fallinjuries (55%), it can be asserted that these safety measures were either not available to mostworkers on site or were not required to be adopted by them as part of the site safety managementsystem. Further research or study or analysis is needed to substantiate this inference. It was also found that there were a small percentage of contractors not reporting the use of any of the safety harness, even though it constituted a major proportion of their accidents. Hit by falling materials was related to be a major source of struck-by accidents by many contractors. Similarly,hit by private vehicles was also found to be a prime cause of struck-by accidents on sites. Using hoist and cranes requires extra cautions in this respect; most contractors indicated that they ensure that workers are not allowed to walk beneath the hoist and cranes. Also, according to a majority, due care was given not to exceed the capacity of the hoist crane. An appreciable proportion of contractors reported to have faced situations whereby their workers had fracture cases owing to injuries caused by improper house keeping such as inappropriate material storage (e.g. wood pieces, steel pieces and nails). Heat stroke was also reported as another frequent cause of injuries on sites [2].
- *Anis, F. (2011);* The primary goal of this research was to study the different accident theories in construction thus to acquire the basic knowledge about the construction accidents and to find out the root causes of accidents at building projects (High Rise), by conducting a questionnaire based survey, so that the industry practitioner may get the necessary knowledge. Statistical analysis was employed to understand the characteristics and determine the leading factors that contribute to construction accidents. The following results were obtained: The most common type of accidents in are the tool accidents (38%), fall from height (21%) and Struck by material (19%); Most of the accidents occurred during the first hours of the day and during the summer season; Most of the workers involved in the accidents were unskilled labor and their literacy rate was very low; The main cause of construction accidents in Pakistan were related to Management and Project nature factors, while the workers and job and social factors were having no large affect, which is an unexpected result. Both workers and supervisors agreed on the ranking of the accident factors. [38]

There were around two fatalities and six injuries related to defective tools and fall from height, as reported in local newspaper addressing whole country. It may also be kept in mind that sectors like transport, services, agriculture, and construction are not covered under the labour protection laws, so the victims do not receive any of the benefits like compensation, injury benefits, death grants and social security coverage available to workers in manufacturing sector. Accident causes due to fall form height and use of defective tools and plant were focused for further investigations for safety climate survey.

Construction Safety Climate

Responses were evaluated on basis of mean value of safety climate statements. This study showed that investigations are mainly used to identify who is to blame (Mean score of statement= 3.61 out of 5.00); People are just unlucky to suffer an accident.(3.28); supervisor/safety manager welcomes reporting safety hazards/incidents (3.70); and accidents which happen here are always reported (3.82); Productivity is usually seen as more important than health and safety by management (3.24); Sufficient resources are available for health and safety here (3.35); working with defective equipment is not allowed under any circumstances in our work environment (3.61); People can always get the equipment which is needed to work to the health and safety procedures / instructions / rules (3.61); Some jobs here are difficult to do safely (3.24); and Current safety rules and procedures enforce the use of personal protective equipment whenever necessary (3.68).

4. RESULTS AND DISCUSSION

Accident records are maintained but the use of statistics is not appropriate even when there is and investigations on construction sites. Main emphasis is on the blame game

among workers, supervisors and managers. Unfortunately, there is no mechanism for compensation for injury or death because of less implementation of inadequate laws. It increases the uncertainty among the workers and they initially blame their luck which has made them victim of construction accident. There is contradiction about reporting accident and/or near miss to the supervisor or manager because not all the accidents are reported and considered. [38] Workers related factors which contribute in happening of accidents;

- The worker was suffering from health problems
- Worker was rushing to finish the work
- Worker was not wearing personal protection items(PPE)
- Physical fatigue caused the accident
- The worker had no satisfaction with the nature of the job
- The accident occurred due to misjudgment from the worker

Specifically, two critical types of accidents associated with Pakistan construction sites are learnt in previous sections. Workers are not allowed to use defective tools or equipment on sites but due to rush of work they have to work with these without wearing PPE. Moreover, workers are not skilled to operate all the tools or equipment e.g. drill machine, welding plant, batching plant etc., and not all the workers are physically strong to do so.

Fall from height is another type of accident which is normally prevailed. Fall from opening or edge or from ladder are the ways such accidents can happen. Workers do not wear proper PPE and they also misjudge the situation due to sufficient resources to execute the activity. Moreover focus on productivity also caused this type of accident.

There is wide difference in situational and perceptional aspects of safety performance. Current study indicated main accidents under lagging indicator of safety performance and their acceptance at perceptional level which showed weak relation between subjected indicators.

Responsibility of accidents is not accepted by either management or workers. Role of supervisors is also critical which relates the safety issues with self-performance. Productivity has been given priority on safety due to tight schedules on construction projects which urge the managers and supervisors to ignore hazardous conditions. Major reason of accident is defective equipment endorsed in psychological perspective including site ergonomics and, plant and equipment. Accident reporting is not efficient as contract based or daily wage workers have job insecurity which leads number of incidents to a severe accident. In light of current study, it is recommended that construction firms should provide flawless tools and equipment and effectively maintain the site environment.

5. CONCLUSIONS

In the current study, leading indicator (i.e. safety climate) has highlighted the neglected safety factors as the use of defective PPE and productivity as priority while working. If these two factors are properly addressed then accident are reduced. Both lagging and leading indicators are significantly related to each other to enhance the safety performance on construction projects.

6. RECOMMENDATION

1. Defective or faulty Personal Protective Equipment (PPE) along with tools, plants and machinery should not be used on construction sites. These equipments should be properly maintained and checked before function. Contrary, unskilled worker using tools is also dangerous.
2. Productivity should not be prioritized over safety during construction processes. Managers and supervisors should address the complexity and situational aspects of construction work. Ignorance may create fatigue and distraction which lead to hazardous situation and ultimately injury or fatality accident.
3. Construction workers should get adequate and certified training to use equipment and get justified work load to avoid pressure from supervisory staff.

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