CONSTRUCTION SITE EHS PLAN: A CASE STUDY OF CONSTRUCTION PROJECT FOR PHARMACEUTICAL INDUSTRY IN KARACHI.

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***ABSTRACT*:** *According to the Labor Force Survey 2013-14 by Pakistan Bureau of Statistics, construction sector employs 4.1 million in Pakistan. It is ranked 5th in the number of employees, but, ranked 3rd in most injury prone industries with alarmingly high injury rate of 14.1%. The objective of this study includes studying the effects of provision of safety equipment and training sessions on Environment, Health and Safety (EHS) condition of a construction site, finding a relation between expenditure and training and suggesting a strategy and tentative budgets for future projects of similar magnitude. The primary data related to the expenditure, budget and trainings were gathered through the EHS department of contractor and project manager. Further, a survey was designed and conducted targeted towards labor. This survey highlights the outcomes of training sessions conducted by EHS department. The training program adopted in the studied project consisted of three phases as follows; induction training, regular trainings/tool box talks and specialized trainings. From the findings of the survey, it was further found that overall awareness of site EHS policy is satisfactory. During the study period, the combined cost of Personal Protective Equipments (PPEs) and Site Safety Equipment reached 2% of the total billed amount to adequately meet the requirements of safety standards. The analysis of the safety parameter's data also suggested that workers' recent experience related to site safety has a significant impact on site safety index. Moreover, number of trainings and strength of the EHS team were founded directly proportional to site safety index. As a strategy for future projects, it is suggested to develop a strong EHS monitoring team, which must be enhanced with the appropriate workforce and a system of trainings.*

Key words: EHS plan, Construction site, Site safety index

1. INTRODUCTION

Both developing and developed countries have realized and understood the importance of construction sector in socioeconomic and sustainable development of a country. Construction activities are closely associated with the various phases of economic development of a country. The activities of this industry have great implications for the achievement of national socioeconomic development goals. The construction sector influences the national economy through construction, renovation, repair and maintenance or extension of long term tangible assets in the form of residential and commercial buildings, urban structures, harbor and ports, dam irrigation system and land improvements of an engineering nature. In addition, the construction sector contributes a substantial proportion of employment in the local market and also acts as a catalyst to the growth of other sectors through its linkages [1].

However the construction sector has the worst records in terms of safety [2] and recognized to be the most hazardous [3]. The working environment of this industry is commonly considered to be 'risky' as compared to other sectors Research studies show that the major causes of accidents in the construction industry are poor safety management involving human behavior, industry practices and site conditions [4].

The safety of an ordinary construction worker is not considered on an absolute prime by majority of construction contractors in Pakistan. For several decades, Pakistani construction workers have been struggling to attain their basic right of health and safety on the job and many of them lost their lives or sustained serious injuries due to unsafe conditions. It could have been avoided by implementing basic safe work practices. The main problem in implementing safety standards is the lack of regulations, budget and awareness.

However, this scenario is rapidly changing. With the introduction of mega projects, well-educated management and funding agencies, along with the allocation of separate budgets for Environment, Health & Safety (EHS) in projects of repute, the EHS conditions are deemed to be improved in the industry [5]. The essence of safe working lies with the change in mindsets of construction workers by constant training and provision of proper personal and site safety equipment to the workforce which should be well suited to the working conditions [6].

This study aims to study the effects of provision of safety equipment and training sessions on the EHS condition of the site both mutually and exclusively. It also attempts to find a relation between expenditure and training in the betterment of EHS conditions. The relation will help in preparing the strategy for better implementation of EHS practices and allocation of appropriate budgets for future projects.

The scope of this study is limited to the study of EHS conditions, implementation methods and provisions of Personal Protective Equipment (PPEs) on a construction project for a pharmaceutical company in Korangi, Karachi.

2. MATERIALS AND METHODS

2.1 Construction sector of Pakistan

Construction refers to realizing a structure in physical form utilizing materials with the help of machinery and manpower [7]. Generally the construction sector can be divided into two categories, first is the residential construction (Housing) which involves individual private housing and the second is commercial construction which comprises of commercial plazas, industries, housing schemes, etc.

Traditional approach of Design-Bid-Build project delivery system is mostly adopted for private commercial projects in Pakistan. The design is being done by architects/engineers and construction handled by contractors with project managers managing the complete project some of the time. The Pakistan construction industry affects about 40 building material industries, through its backward and forward linkages, supports investment and growth, climate which consequently generates employment opportunities for middle to low income households [8]. According to the Labor Force Survey 2013-14 by Pakistan Bureau of Statistics, construction sector employs 4.1 million of total 56.25 million workforce in the country. It is thereby ranked as the 5th largest industry division in terms of employment in Pakistan.

2.2. EHS scenario in Pakistan

The construction sector in developing countries, such as Pakistan and India, employs a labor intensive approach to its processes. On comparison, the labor force in the construction sector for these countries 2.5-10 times higher as compared to developed countries [9]. This sector is ranked third among the most hazardous industries in Pakistan with high injuries, occupational diseases and fatality rates [10].

The advancement in technology has not impacted the site safety situation in the construction industry of Pakistan due to lack of its adaptation. According to Labor Force Survey 2013-14 by Pakistan Bureau of Statistics, Construction Industry ranked 5th in the number of employees but ranked 3rd in most injury prone industries. It has an alarmingly high injury rate, i.e. 14.1% of total workforce of 2.41 million reported some kind of injury at work. This proportionates to approximately 1 in 12 employed people is prone to injuries/diseases in the construction industry [11].

Currently, there is no exclusive regulation of occupational health and safety in Pakistan, The clause 7 of Labor Policy of 2010 dictates that the current labor laws are complex and outdated. It advocates the segregation of labour laws into five (05) major categories including an exclusive category for occupational health and safety.

Further, under clause 25 (Construction Labor) acknowledges the fact that the construction sector is witnessing rapid expansion posing new challenges to health, safety and occupational hazards in this industry. Therefore, the Government shall enact suitable legislation to ensure the health and safety of construction workers. Clause 31 (Health and Safety) substantiates the setup of a Tripartite Council on Health and Safety. This council would be mandated to identify health and safety hazards for workers of all economic sectors and to make recommendations for their avoidance and mitigation. However, the development of this council is yet to be materialized [12].

In the absence of an exclusive regulation for construction sector, other available option is the Hazardous Occupations Rules, 1963 under the authority of the Factories Act. These rules specify some hazardous occupations and authorize the concerned authority to declare any other process as hazardous. The major provisions in this act relate to operational hazards in manufacturing and mining industry which are not specifically tailored to the construction industry.

2.3. EHS practices in the construction sector

A number of studies have been conducted which have explored the state of EHS practices in construction projects and their effectiveness. Mohamed [2] proved through structural equation that management commitment and workers' attitude contributes positively towards the site safety conditions. This aspect has been identified in a number of other studies as well [5, 13-14]. Farooqui et al., [9] has mentioned that this lack of commitment often affects the provision of equipments and staff for site safety. Other identified reasons for deficient site safety conditions in the construction industry include absence of regulatory framework for construction site safety, lack of accurate and detailed data for site accidents, lack of incentives for compliance to site safety practices, insufficient trainings for human capacity building for construction site workers, and lack of involvement of sub-contractors in the site safety processes [6-7, 10, 13, 16-19].

Budgetary constrains play a major role in an organization's commitment to ensuring construction site safety. Lancaster et al. [20] presented a comparison of expenditure on EHS for construction companies. They pointed out that expenditure per employee for site safety, reduces with the increase in size of the construction company. Hence, EHS requirements are more closely followed by large organizations as their benefits seem to outweigh the EHS costs.

Considering the importance of regularizing construction site EHS and capacity development, a joint USAID-HEC project was conducted in 2011-12 in this regard. This project included development of site safety manuals and training programs. However, the recommendations of this project are yet to be realized through any formal body such as PEC.

2.4. Methodology

This study is based on the quantitative paradigm of research. Two types of sources, primary and secondary were utilized to gather the information for this study, it included the following. The primary data related to the expenditure, budget and trainings were gathered through the EHS department of contractor and project management firms working on this project. The study period for this research comprised of 8 months from January to August 2015, and all data stated corresponds to the same time period. In addition to that, the labor satisfaction survey was formulated and conducted exclusively for this paper by the authors. This survey was focused on determining the outcomes of training sessions, conducted by EHS departments, through assessment of the awareness level of safety practices of construction workers. The total planned manpower of contractor was 450 at peak and total expenditure done on the provision of PPEs was PKR 384,500. The contractor's EHS team included 4 personnel at the peak who works under the guidance of the Project Manager's EHS department that forms the holistic EHS Plan for complete project. They conducted a total of 279 meetings during the study period in order to create awareness among the workforce. Risk priority number (RPN) was selected as the Key Performance Indicator (KPI).

The secondary data were gathered by studying the prior research in the area of EHS implementation in the Pakistani Construction Industry and Labor standards of US department of Occupational Safety & Health Administration (OSHA) for the construction industry. The information obtained from these sources guided the direction of research and formulation of study.

3. RESULTS AND DISCUSSIONS

3.1. EHS implementation in pharmaceutical construction project

The pharmaceutical project under study is in construction

stage located in Korangi Industrial Area, Karachi. The area of the plot is 12.5 Acres with total construction area of about 1.5 million sq.ft. The project is designed to comply with Good Manufacturing Practices (GMP) of the World Health Organization (WHO) and Federal Drug Authority (FDA) of USA, keeping EHS conditions on top priority.

The project consist of 3 Production Blocks, 1 Warehouse, 1 Utility Building along with Grid Station and Infrastructure works. It is broken down into 3 major components; namely, civil, electrical and mechanical.

The scope of this study is limited to civil works of production block A and warehouse with construction area of about 0.56 million sq.ft. The planned manpower of a contractor at the peak is 450 persons. Fig 1 shows the average manpower of contractor on site for the period of study taken from daily manpower record supplied by the contractor.

3.2. EHS goals and objectives

The EHS plan for this project is set in accordance with the recommendations from the literature, starting with the commitment from top management. This is evident from the goals and objectives set in the project EHS Plan which are as follows.

1. To achieve a Zero Injury rate for Injuries both ON and OFF the job site, for all personnel.
2. To achieve Zero Motor Vehicle Accidents (MVAs)
3. To achieve Zero traffic situations such as, unsafe driving practice warnings, speeding, etc.
4. To maintain records for the followings:

a. Loss Time Injury Frequency (LTI)
b. Weekly HSSE Audits report.
c. Unsafe Act or Unsafe Condition report.
d. Emergency Drills conducted on site.
e. Vehicle Accident record.
f. Environmental Issue Record.
g. Toolbox Talk Record.

The above objectives were fundamental in determining the activities to be performed and resource utilization for implementing EHS plan. The plan also takes into account the other prime factors identified in the literature, such as workers' trainings, provision of equipment and staff for EHS and regular monitoring of data.

3.3. Personal protective, and safety equipment

As per the record provided by the contractor, the total purchases made and issued to workforce during the study period on account of personal protective and site safety equipment is as given in table 1 to 3. It can be observed that a total of PKR 659,310 (624,630 + 34,680) was assigned for purchase of protective and safety equipment. Equipment worth PKR 240,130 was left unutilized at the end of the study period. The expenditure accrual pattern is depicted in Table 3. The expenditures are increasing at the end of each quarter. However, this observation is constrained by the study period and further observations may reveal different patterns.

3.4. Safety awareness trainings and meetings

Safety meetings on a construction project are an essential tool in the continued development of a mutual understanding of safety objectives and programs. They provide an environment in which individual commitment, effort and ideas can be continuously correlated toward improvement in safety programs and achievements. There are three types of training and meetings which are mentioned in the safety plan of the project, namely Induction Meetings, Tool Box Meetings and Specific Training Meetings.

Induction Meetings are the orientation meetings conducted by the EHS representative in which groups of new employees are trained on the site safety rules and regulations. Tool Box Meetings are short sessions conducted with labor crews on a daily basis in which general practices regarding safe and unsafe condition of works are briefed. Specific Trainings Meetings are conducted to highlight the specific area of site safety protocol and sufficient training is given regarding the selected topic as per the training plan. The number of each of these training sessions held during the reporting period is given in table 4.

It can be observed from table 4 that the tool box meetings were conducted with regular frequency throughout the project. Least number of meetings were conducted for Specific Training Meetings, which is understandable as they are on-need basis. Induction meetings conform to the increase in the labour force (as shown in fig. 1) with a lag of approximately 1 month. So it can be said that workers were given orientation trainings within one month of their hiring.

3.5. Contractors' EHS team

The contractor's EHS department consisted of EHS In-charge and EHS Supervisors, which directly report to him. The contractor's EHS department worked under the guidance of the Project Management firm's EHS department, which forms the holistic EHS Plan for complete project.

The EHS teams were responsible for monitoring daily site activities and record keeping in relation to the EHS Plan. The strength of the contractor's EHS team with respect to time are as follows. 2 personnel were assigned to EHS from January to March 2015, 3 in April 2015 and 4 in May to August 2015.

3.6. Health and safety key performance indicators

Key performance indicators (KPIs) of safety, similar to other processes, referred to as the a set of selected measures to quantify their level of effectiveness. Interventions are made when one or more of these measures show an increase, suggesting that the safety process is weak or weakening. Interventions are implemented in that case to improve the safety process and thereby avoiding the occurrence of major injuries and fatalities (Rehan et al, 2014).

The safety KPIs considered during the said construction project are as follows. They are selected based upon the knowledge and the judgement of the EHS team for construction site safety in Pakistan.

1. First Aid Cases (which includes minor hand injuries, fever, abdomen pain, headache, loose motion, eye irritation etc.)
2. Major Injuries (which require hospitalization)
3. Safety Warning Notices (in case the point of conflict is not resolved by the issuance of unsafe condition notice)
4. Work Stoppage Notices (issued when work is stopped due to unsafe conditions or violation of safety rules)
5. Near Misses (Incidents in which, if care was not taken may result in greater loss).
6. Unsafe Condition Notices

All the above KPIs were observed and recorded in the study period. The record of the occurrence of KPIs during the study period is given in table 5. It can be observed that the first aid cases show the highest occurrences and show an increasing trend during the study period. Interestingly, the total number of occurrences for all KPIs show that it has alternative increasing and decreasing behavior. It could be attributed to the fact that workers become more cautious as they observe/experience more safety related incidents and become careless if it is not so.

A risk priority number (RPN) is calculated for each KPI to co-relate the risk associated with potential problems. Past experience and engineering judgment of EHS team was utilized to rate each potential problem according to three rating scales:

1. Severity, signifying the impact of specific KPI.
2. Occurrence, measuring the likelihood of occurrence for specific KPI.
3. Detection, which shows the likelihood of detection if a specific KPI has occurred.

A rating scale of 1 to 5 was adopted for RPN analysis. The specific rating criteria selected is given in table 6.

After the rating have been assigned, RPN of each issue was calculated using equation (1). The RPNs obtained after performing the analysis on KPIs are given in Table 7.

$$RPN = Severity \times Occurrence \times Detection \quad (1)$$

On the basis of RPN scores and orccurences of each KPI, a weighted site safety index can be calculated against the maximum RPN (27 in this case). Equation (2) was used in this study to calculate site safety index, which is the modified form of equation used by Priyadarshani et al. [21].

$$Site\ Safety\ Index = 1/27 \sum_{i=1}^{n} (RPN_i)(No.\ of\ occurences\ for\ KPI_i) \quad (2)$$

The site safety indices calculated for each month are shown in Table 8. It is to be noted that the site safety index is inversely proportional to the EHS condition on the site, more index is near to 0 better are the site safety conditions. 0 is the absolute index, which means desired site safety conditions. The temporal variation in site safety indices corresponds to that of KPIs' occurrences.

3.7. Relation between safety index and awareness

Fig 2 shows the trend of the site safety index and safety trainings and meetings. It can be observed that safety index tends to decrease with the increase in safety meetings which are intended for awareness of workers for site safety. Hence, it can be said that these meetings and trainings have a positive role in improving the site safety.

3.7. Safety awareness evaluation survey

In order to reinforce the findings from data regarding the status of safety awareness. A survey was formulated to assess the understanding of the EHS policy of the labor. The survey questionnaire was kept simple and designed in Urdu due to poor literacy rate of the targeted population. The questionnaire included 6 nominal questions related to safety awareness which are given in appendix in English for convenience.

A sample size of 30 was selected to conduct the survey, since it is the recommended value to have a normally distributed data [22]. The response received to the questionnaire are mentioned in the table 9.

It can be observed from the response presented in table 9, that majority of the labor force is well aware of the EHS requirements for general working on site, fire incident and medical conditions. The proportion of the correct responses is equal to or above 80%. However, awareness is still required about electrical hazards and working at height whose correct responses were below 80%.

3. CONCLUSION

In this study, an EHS for a contruction project was prepared in accordance with the judgement of local experts and recommendations from research. The effects of the proposed safety plan were measured in terms of workers' awareness and temporal site safety indices. Both these factors show that the intended plan had a positive impact on improving the EHS conditions on the construction project. According to the assessment of graphical relation, the betterment of safety conditions is mostly influenced by the strength of the EHS monitoring team beside provision of PPEs and trainings. Based upon the observations of this study, following strategy is suggested for future projects.

- Develop a strong EHS Monitoring team which needs to be retained for complete duration of the project and must be enhanced with the enhancement of workforce.
- Develop a system of trainings for creating awareness. The trainings can be planned in the same manner as done for this project since they show improvement in site safety conditions.
- Provide general as well as job specific PPEs in a timely manner
- Install display signs creating awareness and motivating the workforce for safe working conditions.
- Conduct periodic safety survey of the work force and arrange specific trainings to encounter deficiencies in training plans.

During the study period a total of PKR 384,500 worth of PPEs and PKR 34,680 worth of site safety equipment was utilized in the same period the total billing for works executed by the contractor was PKR 23,909,680 making it 15.86% of total project cost. The combined cost of PPEs and site safety equipment is 2% of the total billed amount which was found to be adequate to meet the requirements of safety standards set for this project. Therefore, it is recommended for future projects of similar nature EHS Budget to be set at least 2-3% of total project cost. It is to be noted that this budget does not include the cost of EHS monitoring team, which will be on the payroll of the contractor/project management firm.

The observations and conclusions of this research are limited to the construction project under study. These findings can be further enforced / improved by monitoring and analyzing other construction projects from the aspect of site safety.

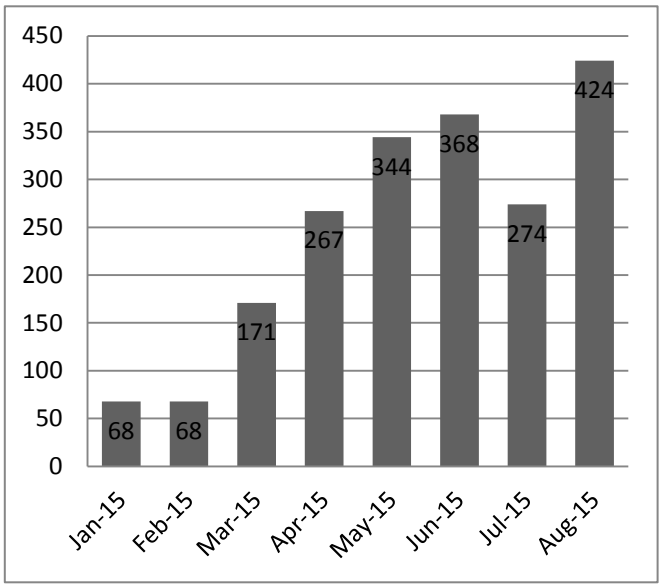

Fig 1: Average man power at sitem.

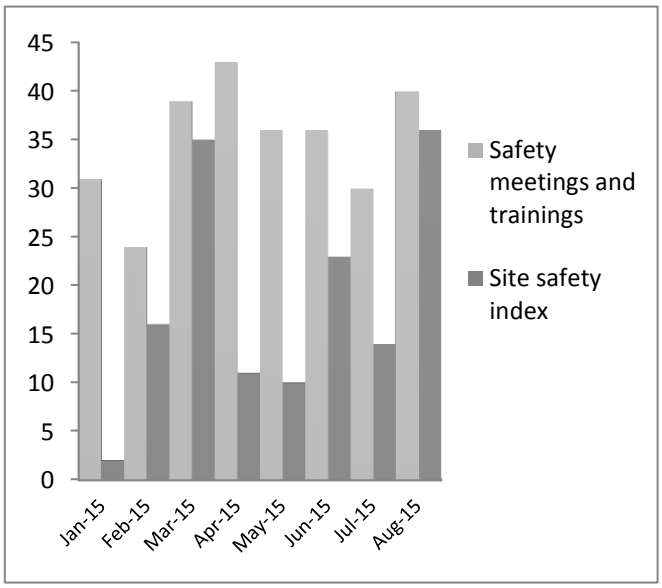

Fig 2: Relation between site safety index and safety meetings.

Table 1: Stock sheet for contractor's PPE

Description			Purchased		Issued		Balance	
	Unit	Rate (PKR)	Qty.	Amount	Qty.	Amount (PKR)	Qty.	Amount (PKR)
1. Personal Protect Equipment								
Safety Helmet	Piece	220	340	74,800	190	41,800	150	33,000
Safety Shoes	Pair	850	395	335,750	245	208,250	150	127,500
LEP-Light Eye	Piece	175	300	52,500	150	26,250	150	26,250
Earplug	Packet	1,200	7	8,400	1	1,200	6	7,200
Cotton Gloves	Pair	20	3,000	60,000	2,200	44,000	800	16,000
Welding Helmet	Piece	1,240	35	43,400	25	31,000	10	12,400
Dust Mask	Packet	210	160	33,600	110	23,100	50	10,500
Face Shield	Piece	480	21	10,080	16	7,680	5	2,400
Welding Gloves	Pair	610	10	6,100	2	1,220	8	4,880
Total				**624,630**		**384,500**		**240,130**

Table 2: Expenditure summary of contractor's site safety equipment

Description	Unit	Rate		Purchased	
				Units	Amount
1. Site Safety Equipment					
Barricading Tape	Piece	300		17	5,100
Fire Extinguisher (6kg-DCP)	Piece	3,000		4	12,000
Fire Extinguisher (6Kg-CO_2)	Piece	5,900		2	11,800
First Aid Box	Box	3,500		1	3,500
Safety Signs (12" x 16")	Piece	120		19	2,280
Total					**34,680**

Table 3: Month wise expenditure summary of contractor's PPE

Month	Expenditure	Expenditure/Labor	Cumulative Total
	(PKR)	(PKR)	(PRK)
Jan-15	52,390	770	52,390
Feb-15	15,390	997	67,780
Mar-15	115,260	1,070	183,040
Apr-15	52,630	883	235,670
May-15	40,010	801	275,680
Jun-15	23,585	813	299,265
Jul-15	21,110	1,169	320,375
Aug-15	64,125	907	384,500
Total	**384,500**		**384,500**

Table 4: Summary of safety meetings and trainings

Month	Induction Meetings	Tool Box Meetings	Specific Training Meeting	Total
Jan-15	4	27	0	**31**
Feb-15	0	24	0	**24**
Mar-15	6	26	7	**39**
Apr-15	10	26	7	**43**
May-15	6	26	4	**36**
Jun-15	4	26	6	**36**
Jul-15	6	24	0	**30**
Aug-15	6	26	8	**40**
Total	**42**	**205**	**32**	**279**

Table 5: Record of KPIs

Month	First Aid Cases	Major Injuries	Safety Warning Notices	Work Stoppage Notices	Near Misses	Unsafe Condition Notices	Total
Jan-15	0	0	0	0	0	4	**4**
Feb-15	0	0	7	4	8	12	**31**
Mar-15	15	0	18	12	3	4	**52**
Apr-15	7	0	2	3	2	0	**14**
May-15	5	0	6	2	0	1	**14**
Jun-15	22	0	3	1	0	2	**28**
Jul-15	16	0	0	0	0	0	**16**
Aug-15	36	0	3	1	0	3	**43**
Total	**101**	**0**	**39**	**23**	**13**	**26**	**202**

Table 6: Rating criteria for RPN analysis

Rating	Description	Criteria
1	Very Low or None	Minor nuisance
2	Low or Minor	Operations can be continued with reduced performance
3	Moderate or Significant	Gradual performance degradation
4	High	Loss of function
5	Very High or Catastrophic	Safety related catastrophic failure

Table 7: RPN of KPIs

KPI	Severity	Occurrence	Detection	RPN
First-Aid Cases	3	3	3	27
Major Injuries	5	1	4	20
Safety Warning Notices	2	3	2	12
Work Stoppage Notices	3	2	2	12
Near Misses	3	1	4	12
Unsafe Condition Notices	2	4	1	8

Table 8: Site safety indices

Month	15-Jan	15-Feb	15-Mar	15-Apr	15-May	15-Jun	15-Jul	15-Aug
Site Safety Index	2	16	35	11	10	23	14	36

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