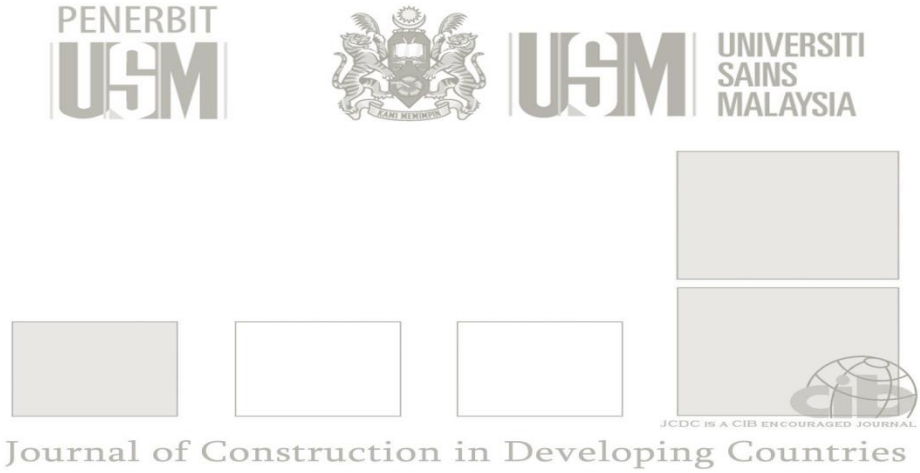

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Exploring the Factors and Measures to Improve Safety in Road Construction in India

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ABSTRACT

Accidents at road construction sites are pervasive in India. Therefore, using data obtained from construction sites on a National Highway in India, the major factors that contribute to the occurrence of accidents were explored in this study, and various strategic and operational interventions that could be implemented to improve safety in road construction were established. A survey was conducted among the relevant stakeholders to collect both quantitative and qualitative data. Inferential statistical methods, including ordinal regression modelling, were used to analyse quantitative data and narrative and interpretive methods were used to analyse qualitative data.

Based on the results, it was found that several factors, related to four important aspects, contribute significantly to the occurrence of accidents, including site conditions, traffic conditions, behaviour and attitude of construction workers, and information and training. It was established that operational interventions, such as the installation of early warning systems, mandatory use of safety equipment and gear, and signage and control at road construction sites can reduce accidents significantly. In addition, strategic interventions, such as implementing a specific road construction safety policy, creating awareness among the stakeholders, and including the cost of health and safety in the project cost are vital. However, it was found that operational interventions are more influential than strategic interventions in the context of safety on road construction sites.

Keywords: Accidents, Construction, Road, Safety, Stakeholders,

INTRODUCTION

The need for an efficient road transportation system to sustain economic growth, the demand for ever-increasing passenger and freight movement, and the challenges of connecting all parts of India created an opportunity for large-scale construction in the highway sector in India. Road construction includes the construction of new highways, expansion of the capacity of the existing highways, and creation of road infrastructure both in the cities and rural areas. In this context, the Government of India (GOI) and several state (provincial) governments have launched initiatives during the past one-and-

a-half decades to modernise and improve the country's road transport infrastructure (World Bank, 2008; GOI, 2018). However, as with every construction activity, the safety of the people, including those who are engaged in construction and road users, is an important concern during construction activities. It is argued that consistent provision of safety systems during the phases of execution, operation and maintenance poses formidable challenges. Moreover, the safe and efficient flow of traffic through work zones remains a major challenge.

While construction activity causes an interruption in the normal flow of traffic as well as accidents, it becomes more critical when construction traffic and normal traffic operate simultaneously. Moreover, it is argued that accident rates are usually higher at roadwork sites and, most often, these accidents tend to involve vehicles operating in, or passing through, the work sites. According to the National Institute for Occupational Safety and Health (NIOSH), it was reported in 2018 that more than 100 workers are killed each year as a result of accidents in road construction in India. Approximately 55% of these fatalities occur within the work zones (NIOSH, 2018). Transportation incidents accounted for 66% of the fatal casualties on roadway worksites, which included workers being struck by a moving vehicle, backing vehicles and incidents involving pedestrians (GOI, 2018). Thus, it was evident that road construction work and vehicular movement during road construction are the major concerns for safety in road construction in India.

To address these challenges, the Occupational Safety and Health Administration (OSHA) developed health and safety standards. Examples of such standards include the use of a different signage system, the provision of safety equipment and gear, and accident prevention tags as a temporary means of warning employees of an existing hazard. Despite the various measures available in theory, the occurrence of accidents at road construction sites, in practice, remains a major challenge and the safety of construction workers, as well as road users, is compromised. Therefore, it is argued that both operational and strategic interventions are essential to improve safety, specifically during the construction of roads. In this context, 'operational interventions' entail observable processes, actions or measures related to the site, context, construction activity being implemented, and weather. 'Strategic intervention' refers to a long-term or future-oriented master plan related to organisation and management, human behaviour, economics, schedule, policy, and legislation. Furthermore, despite safety in road construction being a major challenge, research studies on the various factors that contribute to the occurrence of such incidents, as well as the influence of different interventions to improve safety in road construction in India, are scarce. Therefore, the objective of this study was to explore the various factors that influence the occurrence of accidents on road construction sites and the relative influence of different operational and strategic interventions on reducing the accidents. The research for this study was based on the perceptions and opinions of the road construction workers, road users and various other stakeholders in road construction at different

sections of a project to expand a major highway, the NH55 (old NH42), in the state of Odisha, India. The scope of the data collection was confined to six important sections of the National Highway, where substantial construction activities had been undertaken for its expansion, where it was observed that significant safety challenges had been experienced.

LITERATURE REVIEW

The Challenge of safety in construction is pervasive in India (Das, 2017). Accidents are found to happen significantly in almost all types of construction projects, ranging from the building sector to water structures, roads, railways, and offshore construction (Das, 2019). Road construction is a major part of the construction industry in India and being exposed to different aspects, ranging from organisation and management, and environment to human behaviour, the occurrence of accidents during road construction is significant. Management of health and safety in the construction industry has been emphasised strongly in mainstream literature. Management plays a major role in improving health and safety and can reduce socio-economic losses, time and cost overruns (Abad, Lafuente and Vilajosana, 2013). Despite various efforts being undertaken, the challenges of health and safety continue to prevail, and a significant number of accidents on construction sites continue to occur unabated (Ardeshir and Mohajeri, 2018; Cheng, Kelly and Ryan, 2013; Mohammadi, Mehdi and Khosravi, 2018; Shin et al., 2014).

Although it is argued that accidents in construction happen because of a chain of events resulting from complex, causal interactions among various factors (Bouloiz, et al., 2013; Mohammadi, Mehdi and Khosravi, 2018), two types of factors: strategic and operational, cause accidents in construction, including road construction (Charles, Pillay and Ryan, 2007; Li and Poon, 2013). The strategic factors are mostly indirect and are related to organisation and management, human behaviour, economics, schedules, policy, and legislation, amongst others. Operational factors are generally direct and related to site conditions, site context, construction activities being implemented, and weather conditions, amongst others (Charles, Pillay and Ryan, 2007; Li and Poon, 2013). Also, poor safety and the occurrence of accidents are attributed to certain challenges such as financial constraints, lack of commitment to safety, standards, knowledge and information, restricted training and task selection, and poor-quality control systems (Abdelhamid and Everett. 2000; Awwad, Souki and Jabbour, 2016; Charles, Pillay and Ryan, 2007). Also, attitudes to risk-taking, the nature and type of operations, lack of awareness and proper knowledge of work-related hazards and prevention measures contribute to the occurrence of accidents in construction (Awwad, Souki and Jabbour, 2016; Abdelhamid and Everett, 2000; Jasani et al., 2016; Charles, Pillay and Ryan, 2007). Moreover, unsafe workplace behaviour of the people engaged in construction, such as incorrect use of equipment, negligence during work, failure to warn others of danger, working without authority, not attending safety training, and not adhering to safety and housekeeping rules, amongst others contribute to the

occurrence of accidents (Choudhry, 2014; Mohammad and Hadikusumo, 2019; Zaira and Hadikusumo, 2017). However, the causes of accidents are likely to vary depending on the context, situation, and conditions of the construction work (Charles, Pillay and Ryan, 2007; Meena et al., 2013; Wilson Jr. and Koehn, 2000).

In view of the quantum and implications of accidents, emphasis has been placed on health and safety in general in recent years (Shamsuddin et al., 2015; Wilson Jr. and Koehn, 2000). In India, elaborate provisions for safety have been made in the National Building Code which is a compendium of individual safety codes for mandatory compliance to various safety codes and procedures, such as the Indian Construction Safety Code and minimum health and safety rules at construction sites (Meena et al., 2013). Also, the departments under the Ministry of Labour and Employment have been made responsible for health and safety issues in the construction sector. Organisations, such as the Directorate of General Factory Advice Service Labour Institute (DGFASLI), have been mandated to provide technical support in drafting model rules, carrying out surveys, and conducting training programmes in the construction sector (Meena et al., 2013; MLE, 2011). Furthermore, several laws and acts, such as the Contract Labour (Regulation and Operative) Act, 1970, Minimum Wages Act, 1948, Regulation of Employment and Conditions of Services Act, 1979, and The Building and Other Construction Workers Act, 1996, have been enacted to protect the workers engaged on construction sites (Meena et al., 2013).

However, as mentioned earlier, safety challenges and measures to improve safety in construction vary depending on the context and situation. The challenges of safety in road construction are similar. However, although road construction forms a significant part of the construction industry and roads are being constructed all over the country, while accidents are pervasive on road construction sites, specific studies on the factors that cause accidents during road construction, and plausible measures proposed to reduce accidents, are limited. Also, analyses and evaluations based on the perceptions and viewpoints of stakeholders, specifically on accidents in road construction projects, have been rarely made. So, there was a gap in understanding of the challenges to safety in road construction projects from the points of view of the stakeholders, which it was necessary to explore, hence the reason for this study.

STUDY CONTEXT AND RESEARCH METHODS

Study Context

The National Highway 55 (NH55, old NH42), which passes through the Odisha State in India was used as the context for this study. The NH55 connects the city of Cuttack with the city of Sambalpur and passes through a few important cities and industrial areas such as Chowdwar, Dhenkanal, and Angul. Essentially, the route connects the coal and industrial hub of Angul–Talcher with Cuttack on one side and Sambalpur on the other. Several major

district roads, belonging to Cuttack, Dhenkanal, Angul and Sambalpur District are connected to this road. The highway is a very busy road and bears heavy traffic, including trucks carrying goods and materials from the Talcher mining area and the Angul, Dhenkanal, Chowdwar, and Cuttack industrial areas.

The road construction work was being carried out under Phase-IV of the National Highways Development Project (NHDP) on an Engineering, Procurement and Construction (EPC) basis. The project was envisaged to expedite the improvement of infrastructure in Odisha and assist in reducing the time and cost of travel, particularly for heavy traffic operating between the Angul and Sambalpur Sections. The expansion work took place over a length of approximately 151 kilometres. This major work involved the expansion of the highway to include four lanes. Moreover, other associated works involved the construction of both major and minor cross-drainage works, including bridges. However, since there were no alternative roads to carry heavy traffic during the construction and redevelopment period, the National Highway accommodated construction activities, the flow of construction vehicles, and normal traffic at the same time, which made it a high-risk zone. Therefore, the construction zones on the National Highway sections between Cuttack and Chowdwar, Chowdwar and Dhenkanal, Dhenkanal and Angul were considered to be the context of the study to collect data.

Research Methods

A survey research method was used to collect data. The survey was based on the perceptions of the construction workers and other stakeholders, such as supervisors, contractors, engineers, project managers and technicians, who were engaged in the construction. Two distinct methods were used to collect data. Firstly, a perception survey was conducted among the various stakeholders engaged on the road construction sites. Secondly, qualitative discussions with respondents selected from those who were engaged in road construction were conducted. The perception survey was carried out by using a questionnaire administered to 125 respondents at 6 different road construction sites along the NH55. These 6 sites were chosen because: a significant amount of construction work was being carried out in those sections; their locations were close to important activity centres with significant traffic movement, and the frequency and occurrence of several accidents had been observed. Moreover, since the worksites and construction activities were similar in nature to other construction sites on the National Highway as well as on other similar roads, these 6 sections could be deemed to be representative of all the major construction sites. The respondents included 3 project-related officers (managers), 6 engineers, 8 contractors/ sub-contractors, 8 supervisors, 12 construction vehicle drivers, 6 technicians and 82 construction workers. The selection of the stakeholders was random although based on proportional representations from each category. Although the traffic and road conditions in the different sections were similar, different sections were considered to include the heterogeneity of construction workers to obtain their general perceptions of the safety of

construction on the road and the safety interventions required in the context of the construction sites.

The responses were collected in terms of awareness of the availability of strategic interventions, perceptions of the various factors causing the accidents, and remedial interventions that were considered to be necessary. The data on awareness of the availability of different strategic interventions were collected according to the respondents' degree of agreement or disagreement with the availability or awareness of such interventions. The perceptions of the various factors causing accidents and the plausible influence of various strategic and operational interventions were collected by using a five-point Likert Scale. The points on the Likert Scale used in to measure the factors causing accidents were: 1 = not influential, 2 = less influential, 3 = somewhat influential, 4 = significantly influential, and 5 = most influential. Similarly, the points used to measure the influence of the safety interventions were: 1 = unsafe, 2 = slightly safe, 3 = somewhat safe, 4 = significantly safe and 5 = most safe. The question items related to the causes of accidents were under four important aspects such as site conditions, traffic conditions, behaviour and attitude of construction workers, and information and training related to safety. Similarly, question items related to the influence of strategic interventions included: a special road construction safety policy, creation of awareness, and inclusion of the cost of health and safety in the project cost; and operational interventions such as the installation of early warning signals, mandatory use of safety equipment

and gear, and signage and control measures at the sites. Also, qualitative discussions were held with several stakeholders (12) that included: supervisors (3), contractors (2), site engineers (1), equipment operators and technicians (2), personnel engaged in project management (1), and construction workers (3). These respondents were also selected randomly from the people engaged in the 6 roads construction sites based on their availability and willingness to participate in the discussion.

The respondents' perceptions of safety on the road construction sites were evaluated by calculating Likert Indices. The Likert Mean Score in each case was considered to be the Likert Index. The sum of all Likert Scale Scores assigned by the respondents to one attribute, divided by the number of respondents who indicated their perceptions of that attribute, was calculated to obtain the Likert Index. Standard deviation (SD) was used to check the consistency of the responses and the Z probability was calculated to determine the significance of the responses. A Likert Mean Score (LI) of more than 3 with a high Z probability value (> 0.5) was used to indicate that a factor was influential. Furthermore, the ordinal regression method was used to establish the relative influence of the various strategic and operational interventions on the reduction of accidents. While establishing the relative influence, Road Construction Safety Levels (RCSL) were considered as the ordinal variables and the various safety interventions were considered as the nominal variables. Further, the qualitative responses obtained from the

discussions were analysed by using interpretive and narrative analysis methods.

RESULTS AND DISCUSSION

The results of the analysis have been presented and discussed according to three important aspects: (1) the awareness of, or the availability of information about, strategic interventions, (2) the influence of different factors on the occurrence of accidents, and (3) the interventions necessary to reduce the accidents during road construction.

The Awareness of, or the Availability of Information about, Strategic Interventions among the Workers at the Sites

Awareness of, and information about, strategic interventions for health and safety are critical to avoid accidents in workplaces. The people involved in construction, particularly at the sites, need to have this information so that safety procedures and measures can be implemented effectively. Table 1 shows the status of the awareness of the stakeholders surveyed concerning the availability of strategic interventions for health and safety. The majority of respondents indicated that they were unaware of the availability of a number of strategic interventions to improve safety during road construction. More than seventy per cent (70.4%) of the respondents did not have any knowledge of the availability of a safety policy. Similarly, more than 65% of the respondents were not aware of safety briefings before the commencement of, and during, the work. Also, more than sixty-one per cent

(61.6%) indicated that they were not aware of mandatory regulations regarding safety drills and the use of safety gear. Moreover, more than half (51.2%) of the respondents were not aware of the availability of construction codes of conduct and rules. More than fifty-six per cent (56.8%) of the respondents either did not know or were unsure of the use of technology for early warning and management of traffic. However, it was found that the majority (77.6%) of the respondents knew the availability of general safety rules and regulations. Also, approximately two-thirds (66.4%) were aware of the availability of accident and trauma care facilities and 52.8% knew about the safety equipment and gear. Thus, it was concluded that, except for the basic aspects, such as information about general safety rules and regulations, accident and trauma care facilities, and safety equipment and gear, most of the strategic interventions were not known to the people engaged in road construction.

Strategic interventions	**Yes**	**No**	**Not sure**
Availability of safety policy	15 (15%)	88 (70.4%)	22 (17.6%)
Availability of general safety rules and regulations	97 (77.6%)	28 (22.4%)	0 (0%)
Availability of construction codes and conduct rules	47 (37.6%)	64 (51.2%)	14 (11.2%)
Safety briefing before the commencement of, and during, the work	26 (20.8%)	82 (65.6%)	17 (14.6%)
Availability of safety equipment and gear	66 (52.8%)	51 (40.8%)	8 (6.6%)
Mandatory regulations for use of safety gear	36 (28.8%)	77 (61.6%)	12 (9.6%)
Safety drills	21 (16.8%)	81 (64.8%)	23 (18.4%)
Accident and trauma care facilities	83 (66.4%)	21 (16.8%)	21 (16.8%)
Use of technology for early warning and managing	54 (43.2%)	28 (22.4%)	43 (34.4%)

traffic flow

Table 1. Awareness of strategic interventions among road construction workers

Factors Influencing the Occurrence of Accidents during Road Construction

The various factors that influence the occurrence of accidents during road construction were assessed under four critical aspects: site conditions, traffic conditions, behaviour and attitude of the construction workers, and information and training related to road construction. Table 2 shows the factors that influence accidents during road construction in relation to these aspects. Under the site conditions: lack of barricading and visual signs regarding work zone and work in progress (LI = 4.28, Z_P = 0.949); lack of adequate traffic regulatory signs (LI = 4.14, Z_P = 0.942); lack of early warning and information about work zones (LI = 4.12, Z_P = 0.950); and poor site conditions (LI = 4.01, Z_P = 0.911) were the most influential factors which caused accidents related to site condition. Also, the unavailability of alternative routes or diversions influenced accidents to a certain extent (LI = 3.23, Z_P= 0.659). However, weather conditions had a marginal influence.

Speeding vehicles (LI = 4.11, Z_P = 0.938) was the most important, traffic-related factor which caused accidents during road construction. Also, carelessness or the distraction of drivers or users of roads caused accidents to a certain extent (LI = 3.67, Z_P = 0.68). However, heavy traffic volume, wrong-way driving,

and lack of use of technology for safe driving did not influence accidents significantly.

Under the aspect of behaviour and attitude of the road construction workers, lack of use of safety gear and equipment (LI = 4.12, Z_P = 0.971) was the most important reason for accidents. In addition, the lack of knowledge about safety rules and regulations (LI = 3.82, Z_P = 0.922) and the carelessness of the workers (LI = 3.82, Z_P = 0.939) influenced the occurrence of accidents to a certain extent.

Lack of safety briefings (LI = 4.08, Z_P = 0.935), and lack of safety information and enforcement of safety rules and regulations (LI = 4.02, Z_P = 0.971) were the two most influential factors, related to information and training, that caused accidents during road construction. Also, the lack of safety drills (LI = 3.81, Z_P = 0.908) somewhat influenced the occurrence of accidents.

Factors	Likert Scale Mean Score (LI)	Standard Deviation (SD)	Z score	Z probability (Zp)
Lack of early warning and Information about work zones	4.12	0.68	1.65	0.950
Lack of adequate traffic regulatory signs	4.14	0.72	1.58	0.942
Poor site conditions	4.01	0.75	1.35	0.911
Unavailability of alternative routes or diversions	3.23	0.56	0.41	0.659
Lack of barricading and visual signs regarding	4.28	0.78	1.64	0.949

work zone and work in progress sign				
Weather conditions	2.84	0.49	-0.33	0.370
Speeding of vehicles	4.11	0.72	1.54	0.938
Carelessness or distraction of drivers or users of road	3.67	0.68	0.99	0.838
Heavy traffic volume	2.86	0.56	-0.25	0.401
Wrong-way driving	2.12	0.47	-1.87	0.307
Lack of use of technology for safe driving	2.74	0.51	-0.51	0.305
Carelessness of the workers	3.82	0.53	1.55	0.939
Lack of use of safety gear and equipment	4.12	0.59	1.90	0.971
Lack of knowledge about safety rules and regulations	3.88	0.62	1.42	0.922
Lack of safety information and enforcement of safety rules and regulations	4.02	0.68	1.50	0.971
Lack of safety briefings	4.08	0.71	1.52	0.935
Lack of safety drills	3.81	0.61	1.33	0.908

N= 125

Table 2. Factors influencing the occurrence of accidents during road construction

The Influence of Various Safety Measures on the Reduction of Accidents on Road Construction Sites

The plausible, relative influence of both strategic and operational safety measures on the reduction of accidents was established and the stakeholders' views on the various measures that could alleviate the occurrence of accidents were also sought. The ordinal regression model was used to establish the relative influence of the safety interventions on the reduction of accidents. For this purpose, 6 important interventions (3 strategic and 3 operational) were considered. These interventions emanated from the

discussions with the stakeholders. The Inclusion of the cost of health and safety in the project cost (Intervention 6) was considered as the reference intervention because, according to project managers, it had become an integral part of most of the major projects (see Table 3 below). However, before the influence of the factors was established relative to Intervention 6, the ordinal regression parameters were checked for the validity of the responses. The ordinal regression parameters, which included: model fit information value (significance value: 5.57E-31 < 0.05); goodness of fit value (Pearson value: 0.343 > 0.05); Nagelkerke (Pseudo R^2: 0.730 > 0.70), and test of parallel lines value (significance value: 0.268 > 0.05) were found to be acceptable. Thus, the ordinal regression model was found to be valid and acceptable.

It was found that operational measures, such as installing an early warning system (b = 8.023, exp(b) = 3050,31, p =2.62E - 14), mandatory use of safety equipment and gear (b = 5.986, exp(b) = 397,82, p = 2.79E - 08), and signage and control measures at the sites (b = 5.259, exp(b) = 192,29, p = 0.033) were the three most important interventions in relative order which could reduce accidents. However, the influence of strategic measures, such as road construction safety policy (b = 1.414, exp(b) = 4.11, p = 1.05E - 15), and creation of awareness (b = 1.167, exp(b) = 3.21, p = 8.09E-09) was relatively less, although they still could have a relatively higher influence than the reference intervention (inclusion of the cost of health and safety in project cost) (see Table 3 below). Therefore, at road construction sites, it is essential to

implement operational measures to reduce accidents, although strategic interventions, such as a special road safety policy and the creation of awareness, are also important. The evaluation of the perceptions, indicated on the Likert Scale by the stakeholders, of the various interventions that could improve safety during road construction also supported these findings (See Figure 1).

Furthermore, the interpretations of the qualitative discussions showed that, from the strategic point of view, although health and safety in construction, as well as road safety, have lately been considered seriously, there has not been a specific focus on safety during road construction. Furthermore, there is no specific road construction policy or strategy available at the national level. However, the availability of a safety policy, specifically for road construction, would be likely to assist in alleviating the occurrence of accidents. In this context, a project manager, a site engineer and a supervisor were of the opinion that:

> A road construction safety policy will make it mandatory to observe safety measures at the road construction sites, which might help reducing accidents at road construction sites.

Also, according to a supervisor, a contractor and two construction workers, lack of awareness of various rules, regulations, and safety codes and procedures was a main challenge to managing safety during road construction. They observed that:

> People engaged in road construction should be given proper information and training regarding various safety measures so that they can manage to avoid accidents.

From the operational point of view, the construction workers and supervisors emphasised the importance of early warning systems to provide advance warnings to the construction workers including plant and equipment technicians and operators. They were of the opinion that:

> Sometimes, it is not easy to know the critical situation such as the intrusion of a vehicle or people in the work zone because of the work pressure and noise. An early warning signal will warn the construction workers and plant and equipment operators about the imminent challenge and they can take appropriate measures to prevent the accident.

According to a supervisor, adequate signage and control measures to provide information to the road users and vehicle drivers regarding the ongoing construction works are essential. He stated that:

> Road users, specifically, vehicle drivers get into the work zone if there is no proper signage. The drivers usually become uncertain and sometimes take the risk of driving through the work zone, which causes problems for the construction workers. So, signage and control measures should be made mandatory and should be

provided at different intervals leading to the road construction work zone.

Furthermore, the majority of the respondents suggested that mandatory use of safety equipment and gear during construction work is most essential to improve the safety of the construction workers. Moreover, efforts need to be made to change the attitude and behaviour of the construction workers regarding safety through education and training. Arguably, the combined effect of these measures is likely to improve safety in road construction in India.

Safety intervention number	Safety interventions	Parameter estimates (b)	Relative influence (exponential values) (exp (b))	Significance (p value)	
1	Road construction safety policy (strategic)	1.414	4.11	1.05E-15	Statistically Significant
2	Creation of awareness (strategic)	1.167	3.21	8.09E-09	Statistically significant
3	Installation of early warning system (operational)	8.023	3050.31	2.62E-14	Statistically significant
4	Signage and control measures at	5.259	192.29	0.033	Statistically significant

	the sites (operational)				
5	Mandatory use of safety equipment and gear (operational)	5.986	397.82	2.79E-08	Statistically significant
6 (Reference intervention)	Inclusion of cost of health and safety in the project cost (strategic)	0*	1.00		
	N=125				

Table 3. The Influence of safety interventions on the reduction of accidents on road construction sites

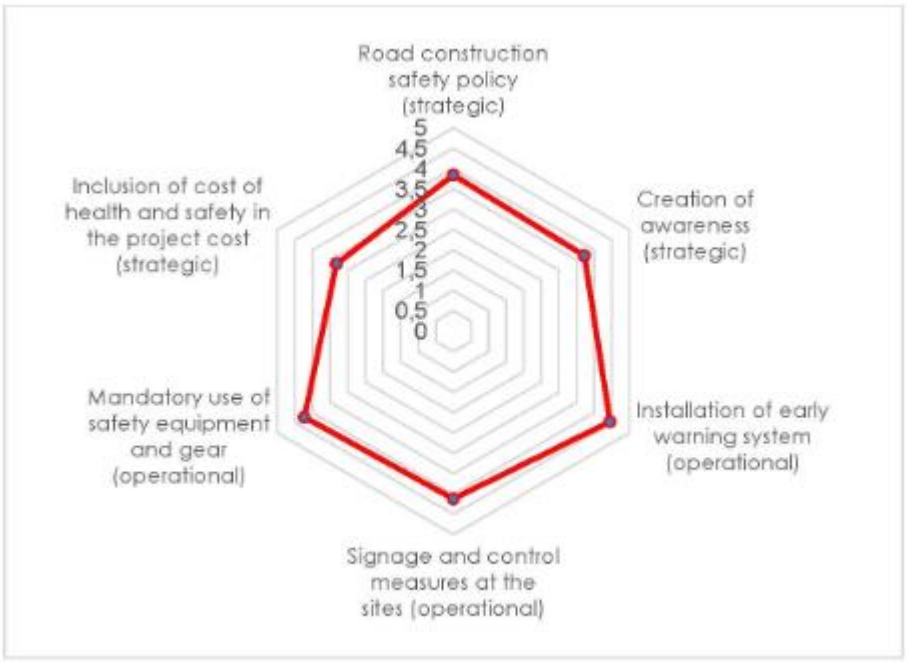

Figure 1. Influence of the safety measures to reduce accidents during road construction (based on ordinal regression model)

CONCLUSION

Significant road construction works are being undertaken to reinforce road infrastructure both at the national and state (provincial) level in India. Consequently, both new construction and upgrading of different categories of roads, ranging from National Highways to smaller local roads, are being undertaken. However, health and safety, specifically in road construction, have received very meagre attention despite the severity of the challenges. It is claimed that various factors influence the occurrence of accidents. Therefore, in this study, by surveying the perceptions of people who were engaged in road construction in different sections of the NH55 (Old NH42) between Cuttack and Sambalpur City of Odisha State in India, the major factors which are instrumental in causing accidents during road construction were explored. The various safety interventions which could reduce accidents also were explored,

It was found that several factors, related to four important aspects: site conditions, traffic conditions, behaviour and attitude of construction workers, and information and training, caused accidents during road construction. Lack of barricades and visual signage indicating a work zone and work in progress, lack of adequate traffic regulatory signs, lack of early warning and information about work zones, and poor site conditions were the major

factors, related to site condition, that caused accidents in the road construction zone. Similarly, speeding and carelessness or the distraction of the drivers were the most important traffic-related factors that caused accidents during road construction. Lack of use of safety gear and equipment, lack of knowledge about safety rules and regulations and carelessness were the major behavioural reasons for the occurrence of accidents. Moreover, matters related to information and training, such as lack of safety briefings, lack of safety information and enforcement of safety rules and regulations contributed significantly to the occurrence of accidents during road construction.

The provision of an early warning system regarding potential safety risks might help to avoid accidents. Moreover, mandatory use of safety gear and equipment by construction personnel, and adequate signage and control measures were of utmost importance and could improve safety in road construction significantly. Similarly, a specific safety policy and the creation of awareness about safety might assist in reducing safety risks in road construction.

The limitation of this paper was that, in the absence of adequate statistical data, the research was based on a perception survey among personnel who were engaged in road construction on selected sites. Despite this limitation, the major factors which influence the occurrence of accidents during road construction and the plausible safety interventions needed to reduce safety

risks were identified in this study. The study contributes to bridging the knowledge gap about safety in road construction and offers insight into stakeholders' perceptions of the causes of accidents and interventions necessary to improve safety in road construction.

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