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Original Article

Measurement and Modeling of Job Stress of Electric Overhead Traveling Crane Operators

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ABSTRACT

Background: In this study, the measurement of job stress of electric overhead traveling crane operators and quantification of the effects of operator and workplace characteristics on job stress were assessed.
Methods: Job stress was measured on five subscales: employee empowerment, role overload, role ambiguity, rule violation, and job hazard. The characteristics of the operators that were studied were age, experience, body weight, and body height. The workplace characteristics considered were hours of exposure, cabin type, cabin feature, and crane height. The proposed methodology included administration of a questionnaire survey to 76 electric overhead traveling crane operators followed by analysis using analysis of variance and a classification and regression tree.
Results: The key findings were: (1) the five subscales can be used to measure job stress; (2) employee empowerment was the most significant factor followed by the role overload; (3) workplace characteristics contributed more towards job stress than operator's characteristics; and (4) of the workplace characteristics, crane height was the major contributor.
Conclusion: The issues related to crane height and cabin feature can be fixed by providing engineering or foolproof solutions than relying on interventions related to the demographic factors.

1. Introduction

Electric overhead traveling (EOT) cranes are major material-handling equipment used in heavy engineering industries. EOT crane operators operate cranes from the cabins and are responsible for unloading, transporting, and loading of various materials. Heavy loads, standardized layout for controls, sequential operations, and lack of training [1] are some of the organizational issues that can make crane operations a difficult and boring task. A study conducted by Eatough et al [2] demonstrated that a high level of role conflict, low job control, and low safety are associated with increased employee stress. Stress, in turn, is related to higher levels of musculoskeletal disorder symptoms of the wrist/hand, shoulders, and lower back. Therefore the operators' stress is influenced by work, workplace, organization, and individual factors.

The individual factors considered were age, education, experience, and job position, whereas the organizational factors considered were workload, role overload, role conflict, role ambiguity, poor career development, and poor interpersonal relations [2–5]. Work-related factors that can cause job stress are demand, control, support, relationship, role, and management of change [6–10].

There is a relationship between major job-related stresses (e.g., workload, lack of control, and interpersonal conflict) and a set of various performance indices [11–13]. Job stress has a

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negative effect on health and wellbeing of the workers in an organization [14]. In a study, Rundmo [12] found some differences in perception of risk amongst employees working in various offshore installation platforms and noted that bad working conditions could lead to higher job stress resulting in work injuries. Staff burnout, a common reaction to job stress, could hamper the human performance, but that could be alleviated by recommended strategies as explained by Cherniss [15]. Some studies were also carried out on the job strain and depressive symptoms in men and women [16]. Wong et al [17] aimed to examine the role of work/nonwork conflict between firemen's job stress and job demand, job support, and family support by structural equation modeling using a questionnaire survey for data collection from 422 firemen. From the result of their analysis, they concluded that work/leisure conflict and work/family conflict mediate partially the relationship between job demand and job control, job support and job stress. The relationship between family support and job stress is fully mediated by work/leisure conflict and work/family conflict [17]. Psychological job characteristics accountable for psychological stress subject to organizational change are also the key factors for increasing the mental stress [18]. Through the literature survey, it has been found that the structural changes within company or any organization can create a set of work-related stressors such as increased job demands (working long hours, more work pressure, and others), less control level, role ambiguity, and more importantly, changes in opportunities for social support from supervisors (e.g., fewer managers, unavailability of proper guidance and recognition, etc.) [18]. Mental stress, which is dependent on these factors, could be augmented along with other consequential effects such as decreased commitment level, less job satisfaction, etc. [19–22]. Many researchers attempted to validate the previous findings on the relation between workers' mental health and job stress level by removing the impacts of unobserved time-invariant confounders [23]. The changing structure of work in society and many organizational factors are responsible for changes in job stress levels [24]. Sometimes, the nature of the work could also affect the level of job stress among workers. Therefore, allocation of work with clear and distinct roles and responsibilities is a necessary factor. Coping with job stress is a key concept in understanding people's adaptation to their work roles. To reduce job stress, Schaufeli [25] expounded a psychological process dealing with various kinds of job stressors called "coping". From this study, it is evident that coping with job stress could handle the stressors encountered during work time. This study illustrated the concept of dynamic interplay of the employee and job environment or work setting considered as stressful in terms of threat or harm [25]. Another research study by Ouyang et al [26] tried to highlight job satisfaction. It discussed the individual differences in emotional intelligence that could influence job satisfaction. Some studies also illustrated the concept of "burnout" caused by excessive and prolonged job stress [27]. Other criteria, such as the macroeconomy, also influence job satisfaction, employee engagement, and level of satisfaction [28]. There might be correlation between depression and work absence indicators that could help the researchers and clinicians adequately assess the job strain of workers in the workplace [29]. Belias et al [30] investigated role conflict, level of job satisfaction, and autonomy of employees in a Greek banking organization. Their findings confirmed that role conflict was negatively correlated with job satisfaction.

Over the years, researchers have been attempting to model job stress under varied conditions of work systems [6,8,31–33]. Four important models developed between 1980 and 2000 are detailed here, which would be helpful for developing the model for the present scenario. Cooper's model [32] considers a number of stressors, e.g., job demand, role in the organization, relationships at work, career development, organization structure and development, and home–work interface, which act as sources of stress on an individual. The job stress model as proposed by Addley [8] is represented as human performance curve. It demonstrates a threshold value of positive stress that is required for achieving good performance. However, increase in stress beyond the limit of positive stress threshold results in a drop in performance, exhaustion, and eventually, burnout or a nervous breakdown. The job stress model proposed by Palmer et al [6] emphasizes the importance of culture and its components as stressors. They considers six potential factors: demand, control, support, relationship, role, and change that are derived from organizational culture and shows that these are manifested into individual symptoms such as tension and high blood pressure and organizational symptoms such as absenteeism, reduced staff performance, and increased hostility. Srivastava and Singh [34] developed a questionnaire containing 46 questions to assess job-related stress and it is being used in the Indian subcontinent. Srivastava and Singh (1981) have given 12 subscales for job stress. They are role overload, role ambiguity, role conflict, unreasonable group and political pressure, under-participation, responsibility for the persons, powerlessness, poor peer relations, intrinsic impoverishment, low status, strenuous working conditions, and unprofitability.

Job stress studies vary by study design, data collection, and analysis schemes used [3,8,35–37]. The primary means of data collection is questionnaire survey [3,8,34,37]. Job stress is not limited to any particular industrial sector and accordingly many studies, models and methods have been developed to deal with this issue. The underlying common technique is the cross-sectional study of questionnaires for the workers concerned. It could be a one-time, two-time (baseline and 12-month follow up) [38] or even three-time observation (baseline, 3-month and 12-month follow up) [39].

The key issues in the job stress study that are yet to be resolved are measurement through questionnaire survey and analysis of survey data. Measurement of the job stress is context- and culture-specific and analysis includes both quantifying job stress and modeling its relationships with contextual variables. For example, it is recommended to use Srivastava and Singh's [34] model for Indian employees for modeling job stress in comparison with models developed elsewhere (e.g., Palmer's model or Cooper's model). It should also be noted here that because the contextual variables change over time and as does culture over long periods of time, the concerned models must be modified to suit the present day requirements. Another important issue is the quantification of contextual variables and their effect on job stress. Lee and Shin [40] have pointed out the problems in quantifying the influence of the contextual variables on the job stress, particularly due to large dimensions with complex relationships. Further, job stress questionnaire data analysis is still in its infancy state, primarily dominated by frequency analysis. Lee and Shin [40] have proposed to use data mining tools coupled with advanced statistical modeling.

Data mining tools provide several advantages over traditional statistical techniques. Data mining techniques, being nonparametric, do not require distributional assumptions. Further, ill conditions and overlapping datasets can be split effectively, e.g., using techniques like the classification and regression tree (CART). The other advantage is that if data contain structural zeros (obvious zero count because of the design of the variable considered), statistical methods often give erroneous results but data mining techniques like CART can overcome this problem.

Owing to the above problems, the present study is important for several reasons. First, it augments the analysis of job stress questionnaire survey data through advanced statistical models such as analysis of variance (ANOVA) and factor analysis. Second, it uses CART to model the relationship of contextual variables with job stress for EOT crane operators in an Indian steel plant. Finally, in this process the study not only modifies the job stress dimensions to measure the stress level of EOT crane operators in the plant studied, but it also provides avenues for EOT crane work system design.

The rest of the paper is organized as follows. In the Materials and methods section, the proposed methods are discussed along with their application to EOT crane work systems. The key findings and their implication and also the conclusions are discussed in the Results and Discussion section.

2. Materials and methods

2.1. Variables and instruments

Two types of variables are considered: the criterion and the predictor variables (Fig. 1). The criterion variables are the dimensions of job stress: employee empowerment (EE), role overload (RO), role ambiguity (RA), rule violation (RV), and job hazards (JH). The predictor variables comprise the demographic factors: age, experience, body weight, and body height of the crane operators and the task and workplace factors are exposure hours, cabin type, cabin features, and crane height.

To measure job stress, the Occupational Stress Index developed by Srivastava and Singh [34] was used as this was designed for shop-floor employees working in India. As Srivastava and Singh's questionnaire was developed in 1981, its relevance to present industrial situations is a bit questionable. Hence, a brainstorming study involving plant personnel, crane operators, expert managers, and occupational health and safety doctors of the plant was conducted to design a questionnaire more suitable for the study. In addition, models of the job stress such as the one developed by Cooper [6,8,32] were critically reviewed to formulate the proposed model. Five subscales are proposed: EE, RV, RO, JH, and RA (Fig. 1). Then, the original 46 questions of Srivastava and Singh [34] were judicially split across five modified subscales as shown in Appendix 1.

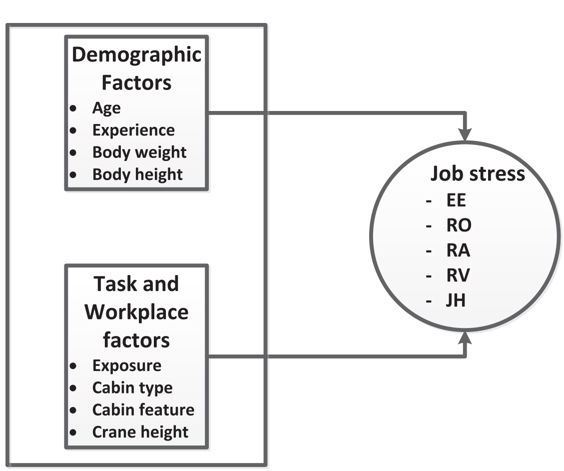

Fig. 1. Relationship model for job stress with demographic, task, and workplace factors. EE, employee empowerment; JH, job hazard; RA, role ambiguity; RO, role overload; RV, rule violation.

2.2. Sample and data

A cross-sectional study was conducted involving 76 EOT crane operators, operating 33 cranes in the cold rolling mill under flat product rolling of an integrated steel plant in India. A crane operator was engaged in moving heavy objects on the ground by sitting in the crane cabin at a particular height (30, 40, or 60 feet).

The relevant data to capture demographic variables, working conditions, and job stress were collected using two sets of questionnaires: (1) the questionnaire of occupational stress index (OSI), and (2) the questionnaire developed in this study to capture the demographic information and the working conditions of the crane operators. Data collection was done either at the beginning or at the end of the shift with the help of trained personnel. The purpose of the study was explained and confidentiality was ensured to all the crane operators before collecting their data. Supervisors were not included in the study as the answers given by the operators might be biased in their presence but their prior consent was obtained. To reinforce the confidence of the crane operators, one occupational health and safety doctor was included in conducting the questionnaire survey.

Initially, 46 questions were considered and the 12 OSI subscales were determined as per the scheme provided by Srivastava and Singh [34]. Most of the subscales suffer from negative Cronbach α, which necessitates revision of the dimensions as well as the questions. Moreover, as the number of dimensions was large (12 in number), factor analysis of the original 46 questions based on the 76 respondents was carried out. Both unrotated and rotated factor analyses were done but no clear cut factor patterns were identified. This may be attributed to the small sample size compared with the number of questions. Increase in sample size was prohibitive from time, cost, and conventional point of view as the work was done in industrial setting. This necessitates the use of the researchers' knowledge in predefining the factors (dimensions) with appropriate manifest variables. The validity of the modified dimensions with indicator questions was determined by computing Cronbach α coefficient values for each of the dimensions, which are 0.65 for EE, 0.61 for RO, 0.62 for RA, 0.62 for RV, and 1 for JH (Table 1). The Cronbach α coefficients are above the acceptable level (>0.60, Nunnally [41]). These 37 questions are comparable with the job stress questionnaire with 30 questions developed by Addley [8] and are found to cover all the fields affecting the job stress.

2.3. Model and analysis

In this study, all the predictor variables were made categorical in nature. For example, age was measured in three categories namely, operators $\leq$ 35 years of age, operators with age between 36 and 45 years (age was converted into nearest integer), and operators above 45 years of age. The criterion variable job stress and its subscales

Table 1
Modified subscales and relevant questions used for the crane operators

Serial No.	Subscales of OSI	Questions*	Cronbach α
1	Employee empowerment (EE)	5, 6,7, 8, 9, 10, 11, 18, 19, 20, 21, 22, 23, 29, 30, 31, 33, 34, 40, 42	0.65
2	Role overload (RO)	1, 12, 13, 17, 25, 28, 44, 46	0.61
3	Role ambiguity (RA)	2, 3, 37	0.62
4	Rule violation (RV)	4, 16, 38, 39, 45	0.62
5	Job hazard (JH)	24	1.00

OSI, occupational stress index.
* The numbers shown are as per the original numbers of OSI [34] and Cronbach α represents the reliability of the items considered.

were used as a continuous variable (using summated score) or categorical (based on quartile values). The job stress model answers the following two questions:

Question 1: Are there differences amongst the predictor categories of each of the variables in explaining job stress or its subscales?

Question 2: What is the relative degree of influence of each of the predictor variables in explaining job stress synergistically?

To answer the first question, the ANOVA model was used. As there were eight predictor variables with 19 categories altogether, and because of practical limitations, ANOVA was conducted separately for each of the variables as all the variable categories collectively create combinations of zero frequency. These zero frequency cells (combinations) are known as structural zeros, which distort the estimation process and are better to be avoided. For the same reason, no parametric statistical tools (e.g., logistic regression) were used to answer Question 2; instead, CART, a nonparametric technique was used to answer it.

For ANOVA, the data structure is shown in Table 2. For example, the predictor variable age is grouped into L levels (i.e., Age1, Age2, ..., AgeL) and $n_l (l = 1, 2, .., L)$ observations on the predictor variable level l, are collected.

Now, with respect to Table 2, an observation y_{li} can be written as

$$y_{li} = \bar{y} + (\bar{y}_l - \bar{y}) + (y_{li} - \bar{y}_l)$$

$$= \bar{y} + \gamma_l + \varepsilon_{li} \quad (1)$$

Where, γ_l is the main effect of the l-th level (category) of the predictor variable.

ANOVA tests the following hypothesis:

H_0: $\bar{y}_1 = \bar{y}_2 = \ldots\bar{y}_l = \ldots = \bar{y}_L$

H_1: $\bar{y}_l \neq \bar{y}_m$ for at least one pair of (l, m) combination.

A test statistic F was used to test H_0 with a level of significance α which was set equal to 0.05 (i.e., $\alpha = 0.05$).

If H_0 is rejected, one can conclude that the criterion variable job stress differs across the predictor variable categories.

To answer Question 2, CART [42] was used. It provides a decision tree using binary recursive partitioning algorithm. The tree consists of three types of nodes namely, root node, internal nodes, and leaf nodes. For example, if one wants to predict job stress as a categorical variable with three classes namely, low, medium, and high level of stress with the help of predictors such as age, experience, and other demographical variables and/or with workplace factors, the root node starts with the criterion variable (job stress in this case). The root node is then split into two nodes taking into consideration one of the predictors (e.g., age). These two nodes can either be treated as internal or leaf nodes where the leaf node is the end node that cannot be split further but the internal node can be split further with the help of one of the predictors. In this manner, the recursive split continues.

Table 2
ANOVA data structure

Predictor variable levels	Observations	Average
Level 1	$y_{11}, y_{12}, \ldots, y_{1n_1}$	$\bar{y}_1$
Level 2	$y_{21}, y_{22}, \ldots, y_{2n_2}$	$\bar{y}_2$
:	:	:
Level l	$y_{l1}, y_{l2}, \ldots, y_{ln_l}$	$\bar{y}_l$
:	:	:
Level L	$y_{L1}, y_{L2}, \ldots, y_{Ln_L}$	$\bar{y}_L$
	Grand mean	$\bar{y}$

ANOVA, analysis of variance.

CART involves three steps namely tree growing, stopping, and prediction. For growing, the steps involve: (1) find each predictor's best split, (2) find each node's best split, and (3) split a node using the best split. The best split is determined based on impurity criterion where impurity is a measure of lack of homogeneity of a node in separating the classes of the criterion variable. To measure impurity the Gini index [43] as defined below was used.

$$Gini = 1 - \sum_{i=0}^{c-1} [p(i|t)]^2 \quad (2)$$

Where, $p[i|t]$ denotes the fraction of records belonging to class i at a given node t and c is the number of classes. The best split is the one which possesses the least impurity. Generally the splitting continues until the improvement in impurity due to additional splits is not significant.

To augment the accuracy of the CART model 10-fold cross-validation was performed. In 10-fold cross-validation, the whole data set is divided into 10 numbers of subsets. Each time a subset (sample) is dropped and the model is developed using rest of the data. The model is then used to predict the values of the dropped out subset and misclassification rate is computed. Then the sum of errors over 10-fold cross-validation is estimated. The process is repeated and finally the tree with the smallest estimated error rate is selected.

It should be noted here that multiple linear regression (MLR) could be used to model the situation as the dependent variable (job stress) is continuous in nature. We have adopted CART for two reasons: (1) we have categorized the job stress variable into three groups, i.e., operators with "low job stress", "medium job stress", and "high job stress". It helps in decision making by classifying operators into three broad groups and taking actions for high stress group of operators. MLR is not applicable for categorical dependent variable. (2) To avoid the problem of normality and homoscedasticity assumptions of MLR. CART, being a nonparametric approach, is able to handle ill-conditioned data and nicely partition them across the predictor groups. Another alternative could be logistic regression for categorical dependent variable but it suffers from the parametric assumptions of the log-odds transformation.

3. Results and discussion

The results obtained from ANOVA model are shown in Tables 3 and 4.

From Tables 3 and 4, it is seen that majority of crane operators are in the age group of 35–45 years (69.70%) and weight >65 kg (55.26%). Almost 47% have work experience of more than 5 years and 52.63% are more than 5 feet 6 inches (1.68 m) tall. The majority of crane operators (77.6%) use type B crane cabin, whereas only 22.4% use type A crane cabin. 51.3% operators operate with movable crane cabin whereas 48.7% operate with a static cabin. 69.71% crane operators operate at a crane height of 30 feet and 77.6% are exposed to work for 36 h/wk.

On comparing total and subgroup stress scores with operators' demographics and workplace characteristics, ANOVA suggests that significant differences in stress scores prevail in the following areas:

- Between operators weight groups (≤65 kg and >65 kg) for EE,
- Between type A and type B cabin type for RA,
- Between movable and static cranes for JH,

Table 3
Differences in job stress across demographic factors of crane operators

Variables	Category	Percentage of employee	Mean					Total
			EE	RV	RO	JH	RA	
Age	≤35 y	11.8	51.89	14.11	27.11	4.44	6.55	104.11
	35–45 y	69.7	52.22	14.24	26.36	4.20	6.77	103.81
	>45 y	18.4	52.5	14.5	27.71	4.35	6.14	105.21
p			0.971	0.933	0.341	0.419	0.331	0.908
Experience	≤5 y	52.6	52.03	14.13	26.33	4.28	6.45	103.2
	>5 y	47.4	52.47	14.44	27.11	4.25	6.83	105.11
p			0.741	0.602	0.286	0.851	0.240	0.433
Weight	≤65 kg	44.74	53.53	14.68	27.03	4.36	6.58	106.15
	>65 kg	55.26	51.19	13.95	26.45	4.22	6.67	102.45
p			0.082	0.237	0.418	0.413	0.812	0.129
Height	≤5 ft 6 in	47.37	52.94	14.78	27.00	4.26	6.44	105.42
	> 5 ft 6 in	52.63	51.60	13.83	26.42	4.26	6.80	102.92
p			0.318	0.117	0.436	0.851	0.276	0.305

EE, employee empowerment; ft, feet; in, inches; JH, job hazard; RA, role ambiguity; RO, role overload; RV, rule violation.

Table 4
Differences in job stress across task and workplace factors of crane operators

Category	Types	Percentage of employees	Mean					Total
			EE	RV	RO	JH	RA	
Exposure	24 h	10.52	52.00	14.13	26.25	4.38	7.50	104.25
	36 h	77.63	52.14	14.23	26.78	4.32	6.46	103.83
	48 h	11.84	53.11	14.67	27.22	3.78	7.00	105.75
p			0.892	0.891	0.821	0.023	0.103	0.877
Cabin type	Type A	22.4	51.65	14.41	26.77	4.29	7.23	104.35
	Type B	77.6	52.41	14.23	26.68	4.25	6.45	104.03
p			0.639	0.812	0.922	0.803	0.045	0.913
Cabin feature	Movable	51.3	51.64	14.21	25.38	4.15	6.71	103.10
	Static	48.7	52.86	14.35	27.03	4.37	6.54	105.16
p			0.363	0.811	0.383	0.089	0.588	0.397
Crane height	30 ft	69.7	53.77	14.64	27.26	4.28	6.56	106.53
	40 ft	18.4	49.23	13.57	25.50	4.21	6.34	99.07
	60 ft	11.8	47.56	13.22	25.22	4.22	7.44	97.67
p			0.001	0.180	0.060	0.903	0.164	0.008

EE, employee empowerment; ft, feet; JH, job hazard; RA, role ambiguity; RO, role overload; RV, rule violation.

- Among different crane heights for total job stress, EE, and RO, and
- Among exposure periods for RA and JH.

Whereas ANOVA was used to find out the effect of individual predictors on job stress and its dimensions separately, CART was used to determine the collective effect of the predictors on the overall job stress levels of the EOT crane operators. To develop the CART model, the overall job stress was divided into three categories as per the following rules.

Rule 1: If an operator's job stress score is less than or equal to the first quartile value, the operator is subjected to a low level of job stress.

Rule 2: If an operator's job stress score lies within the interquartile range, the operator is subjected to a medium level of job stress.

Rule 3: If an operator's job stress score is greater than or equal to third quartile value, the operator is subjected to a high level of job stress.

The classification tree map structure is shown in Appendix 2. Appendix 2 Fig. 1 represents the overall tree structure where the nodes are represented using numbers. Because the original tree structure is very large in size to be represented in a single page, the original tree model has been shown in parts in subsequent figures. The classification trees for job stress of the crane operators are shown in parts starting from Appendix 2 Fig. 2B.

Because the data samples collected were only 76 in number, bootstrapping was done before developing the CART model. The bootstrap sample size was 1,000; 10-fold cross-validation was done for increasing the classification accuracy. To determine the contribution of individual predictors on job stress, CART calculates importance score for each of the predictors. The important scores of the predictors are shown in Table 5. It can be noted that age, crane height, cabin feature, operator's weight, operator's experience exposure time, and cabin type are important factors contributing to the development of job stress on the crane operators. The relative importance of these factors is also derived based on normalized importance, which is computed as a ratio of

Table 5
Importance of predictor variables

Independent variable	Importance	Normalized importance
Age	0.159	100.0%
Crane height	0.092	57.8%
Cabin feature	0.085	53.5%
Operator weight	0.075	47.3%
Experience	0.065	41.1%
Exposure	0.054	33.9%
Cabin type	0.048	30.4%
Operator height	0.025	15.7%

Table 6
Classification table using CART

Observed	Predicted			
	1.00	2.00	3.00	Percent correct (%)
1.00	551	73	141	72.0
2.00	113	1,167	220	77.8
3.00	0	151	584	79.5
Overall percentage (%)	22.1	46.4	31.5	76.7

CART, classification and regression tree.

individual importance to the maximum importance of the predictors (Table 5).

The predictive ability of CART is measured using a classification table (see Table 6). For the study, CART correctly classified 76.7% of the overall cases.

The study results show that crane operators differ in stress related to EE for demographic predictor age, body weight, and workplace predictor crane height. An interesting proposition regarding body weight- and EE-related stress is that operators with lower body weights suffer from higher stress levels. This may be because of the fact that the less obese operators have higher agility, which makes them more active and hence look for higher empowerment. However, operators of 30 feet high cranes feel more stress related to EE, which is of concern to the company studied. To improve this, major interventions may be needed. Management should look into the matter as to why operators of 30 feet high cranes suffer from EE-related stress. One of the reasons could be the nature of the job. As operators of 30 feet high cranes carry out routine jobs of placement of materials at the ground level, they find it monotonous.

Although RV is perceived to be an important component of job stress, none of the predictor variables shows a significant relationship with it. This nonsignificant relationship may be interpreted that a certain level of RV may be an acceptable fact across the EOT crane operators irrespective of their job profile. The RVs can be reduced with engineering and administrative interventions. Operators working in 30 feet cabins have more RO-related job stress compared with operators working in 40 feet and 60 feet height cranes. In consideration of JH, static cabin operators perceive more JH as compared with movable cabin operators. One of the reasons could be that the movable crane operators have more flexibility to maneuver the machine and hence feel more secure to combat any hazard-related situations as compared with static cabin operators.

Finally, the CART model indicates that operator's age, crane height, cabin feature, operator's weight, experience, exposure time, and cabin type are important factors that collectively contribute to the development of job stress in crane operators. Therefore management should consider the collective effect of the predictors while designing interventions for reducing job stress.

It should be noted here that some of the predictors considered could be dependent on themselves or there could be confounding effects. The problem of confounding can be handled in CART with proper selection of the method of tree construction, amount of pruning, and use of resampling methods such as bootstrapping. In addition, the problem of confounding is lessened as CART often implicitly deals with interactions and nonlinearities.

In this study, a job stress model was developed for capturing significant predictors of job stress amongst EOT crane operators. The model considered five dimensions of job stress namely EE, RO, RA, RV, and JH. The association between the predictors and the overall job stress and its dimensions was tested. Operator's age contributed the most, followed by cabin height, cabin feature, operator's weight, and operator experience. The assumption that the operators working at a higher crane heights (e.g., 60 feet) will face more job stress as compared with the operators working at lower crane heights (e.g., 30 feet) was not established in this study. A closer comparison into the facility provided for 60 feet versus 30 feet cranes revealed that operators of 60 feet high cranes operate with movable cabin for fewer (24 h/wk) exposure hours as compared with the operators of 30 feet high cranes who work with a static cabin for 48 hours of exposure. Hence, it is essential for the management to ensure that the operators are not exposed to all these situations simultaneously. They should provide interventions, at least, to one of the categories to reduce the job stress on the operators. Among the job stress dimensions, poor EE causes more stress and the operators' weight and crane height are the major differentiating predictors. EE can be related to the control and support dimensions of job stress developed by health and safety executive, UK (HSE, 2001). The higher job stress related to poor EE can be tackled by allowing operators to control their pace of work, and providing support through developing skills and knowledge of the jobs assigned. The dimensions RO, JH, and RA impose demand on the work. A certain level of demand is necessary but beyond a limit, it causes job stress [8]. Hence, improved EE can act as an energizer resulting in higher work compatibility under high demand crane operations, which in turn reduce the job stress. This supports the concept of work compatibility developed by Genaidy et al [44]. In summary, this study supports the existing concepts and models as discussed above and in addition, it brings out a few new predictors of job stress for EOT crane operators such as crane height, cabin feature, and crane type, which are not reported in the job stress literature.

Although the study contributes in developing and testing the job stress model for EOT crane operators, it is subjected to certain limitations that should be kept in mind while implementing the research outcomes. First, the study incorporates empirical research methodology, which is governed by the data collected from the field. Questionnaire-based perception data on job stress are used. Use of self-reported questionnaire data may provide biased information because of lack of understanding or perception. The results from the study as obtained are subjected to the adequacy of the questions used and reliability of the responses provided. As the study is carried out at a particular location, findings cannot be generalized to all parts of the working system. More replication studies are required. Finally, inclusion of a comparison group within a similar work environment may provide a better idea of the job stress of crane operators and its relation with work conditions.

It is believed that data mining is useful and is was shown that the problem studied deserves the use of CART. Bootstrapped samples were used for CART and thereby the problem of small sample was taken care of. The study shows the successful application of CART. It is also to be noted that a parametric hypothesis-based study (e.g., MLR or logistic regression) could have been done, but may be considered as the scope for future researchers to make a comparative study of CART, MLR, and logistic regression for the evaluation of job stress.

Conflicts of interest

There is no conflict of interest.

Acknowledgments

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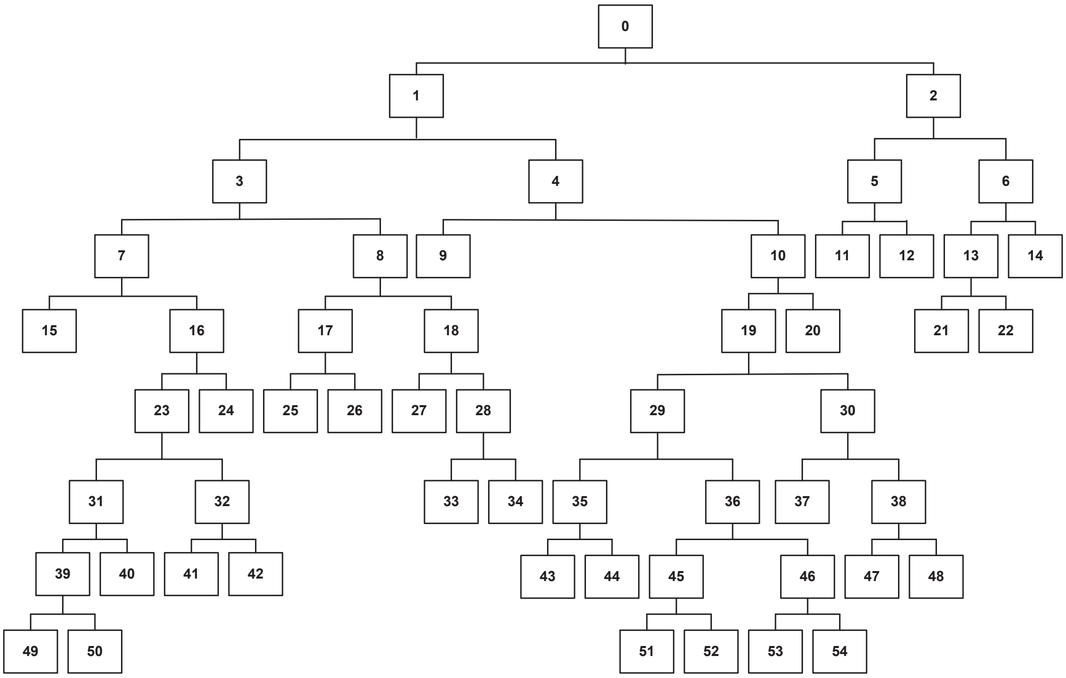
Appendix 1. Modified job stress questionnaire (Modified after Srivastava and Singh [34]).

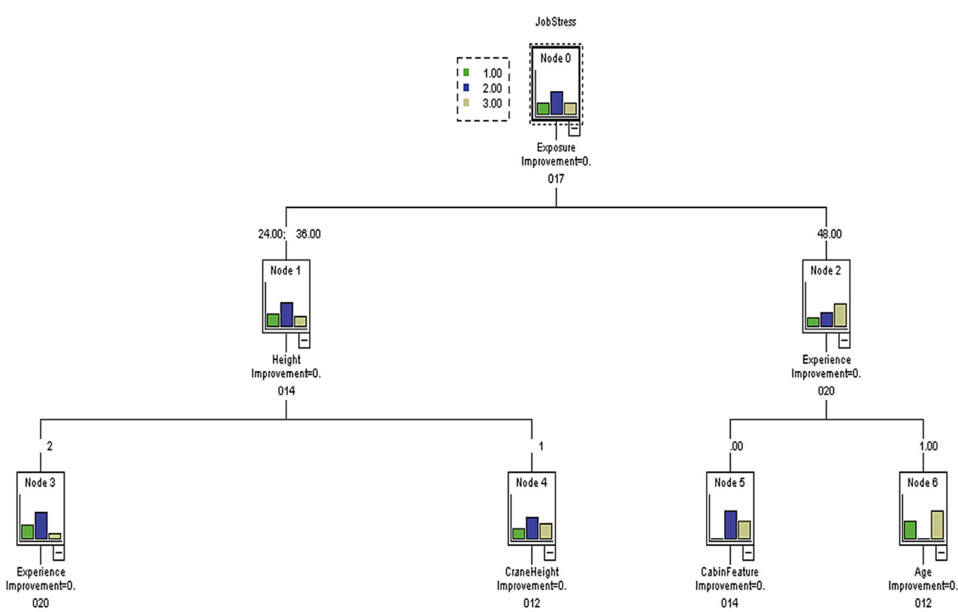
Subscale	Original Q. No.	Question*
Employee empowerment	5	The responsibilities for the efficiency and the productivity of the many employees are thrust upon me.
	6	Most of my suggestions are heeded and implemented here.
	7	My opinion on distribution on assignments is properly considered.
	8	I have to work with persons whom I like.
	9	My assignments are of monotonous nature.
	10	Higher authorities do care for me and respect.
	11	I get less salary in comparison to the quantum of my labor/work.
	18	My co-operation is frequently sought in solving the departmental safety and occupational/health related issues.
	19	My suggestion regarding the training programs of the employees are given due significance.
	20	Some of my colleagues and subordinates try to defame and malign me as unsuccessful.
	21	I get ample opportunity to utilize my abilities and experience independently.
	22	This job has enhanced my social status.
	23	I am seldom rewarded for my hard labor and efficient performance.
	29	I bear great responsibilities for the progress and prosperity of this organization.
	30	My opinions are sought in framing important policies of the organization.
	31	Our interest and opinions are duly considered in making appointments for similar posts.
	33	I get ample opportunity to develop my aptitude and proficiency properly.
	34	My high authorities do not give due significance to my post and work.
	40	My opinion is sought in changing or modifying my job related working system, instruments and conditions.
	42	My suggestion and cooperation are not sought in solving even those problems for which I am quite competent.
Role overload	1	I have to do a lot of work in this job.
	12	I do my work under tense circumstances.
	13	Owing to excessive work load I have to manage with insufficient no. of employees and resources.
	17	I am responsible for the future of a number of employees.
	25	I have to dispose of my work hurriedly owing to excessive work load.
	28	In order to maintain group-conformity, sometimes I have to do/produce more than the usual.
	44	I have to do such job as ought to be done by others.
	46	I am unable to carry out my assignments to my satisfaction on account of excessive work load and lack of time.
Role ambiguity	2	The available information relating to my job, role and its outcomes are not clear.
	3	My different officers often give contradictory instructions regarding my works.
	37	It is not clear what type of work and behavior my higher authority and colleagues expect from me.
Rule violation	4	Sometimes it becomes complicated problem for me to make adjustment between political/group pressures and formal rules and instructions.
	16	I have to do some work unwillingly owing to certain group/political pressure.
	38	Employees attached due importance to the official instructions and formal working procedures.
	39	I am compelled to violate the routine administrative procedures and policies owing to group pressure.
	45	It becomes difficult to implement all of a sudden the new dealing procedures and policies in place of those already in practice.
Job hazard	24	Some of the assignments are quite risky and complicated.

* The response to each question is measured on a 5-point Likert scale: 1, strongly disagree; 2, disagree; 3, undecided; 4, agree; 5, strongly agree.
Original Q. no., original question number.

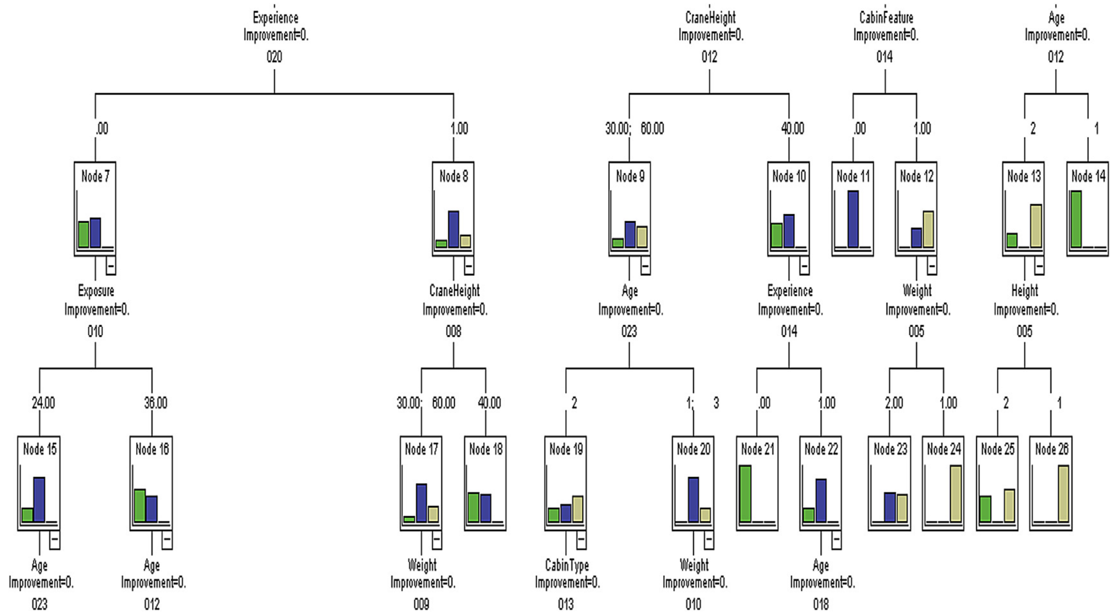
Appendix 2. Classification and regression tree (CART) results.



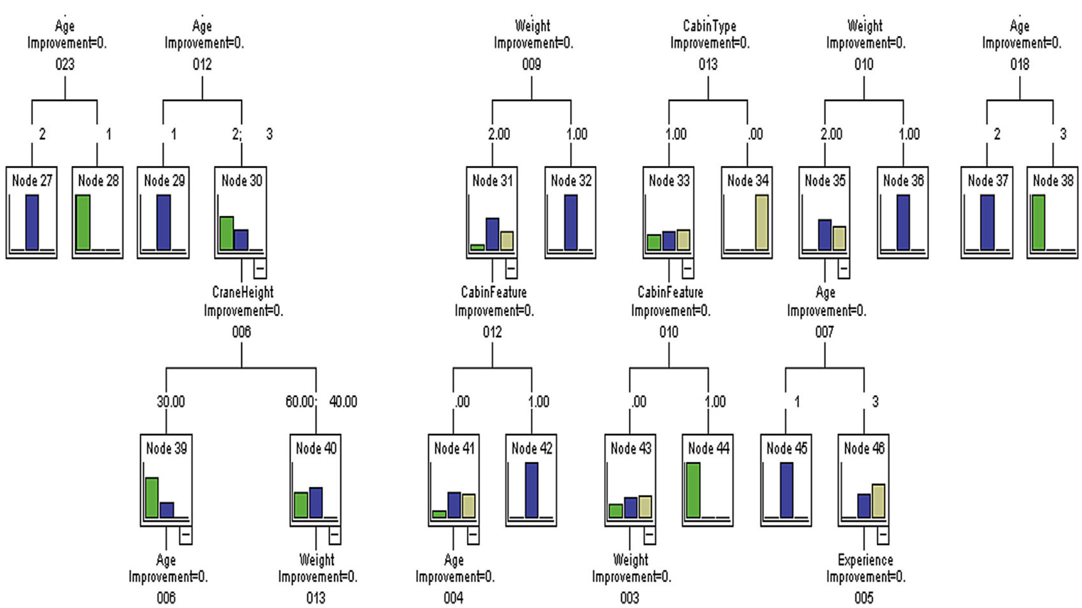
Appendix 2. Fig. 1. Classification tree map structure.



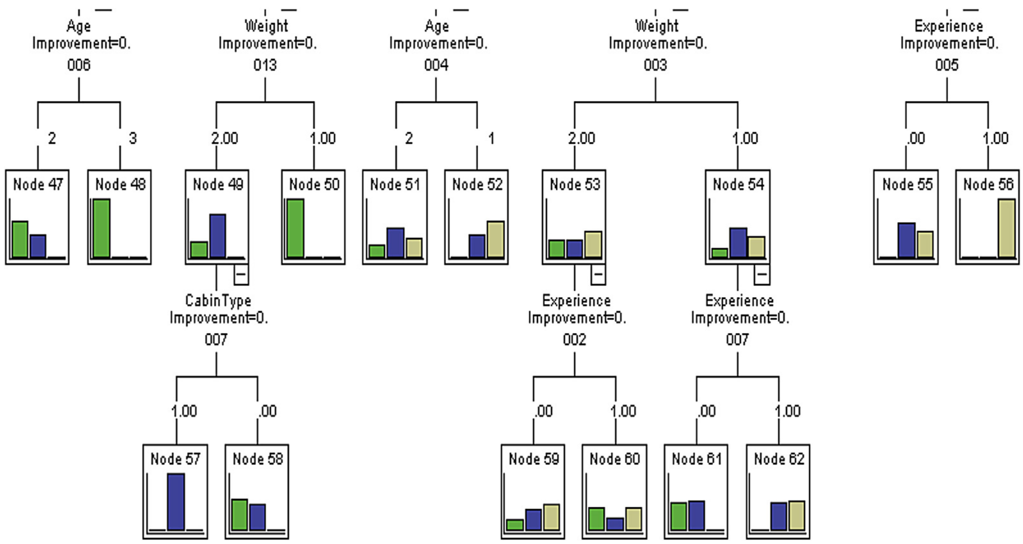
Appendix 2. Fig. 2. CART model node (1–6). CART, classification and regression tree.



Appendix 2. Fig. 3. CART model node (7–26). CART, classification and regression tree.



Appendix 2. Fig. 4. CART model node (27–46). CART, classification and regression tree.



Appendix 2. Fig. 5. CART model node (47–62). CART, classification and regression tree.

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