Determinants of Health and Safety Management in Construction Industry; the Case of Hengyang City, China

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Abstract: The construction industry promotes the development of national social economy and provides necessary infrastructure and enhanced facilities for social comfort. However, it is the most hazardous industries due to high occupational risks and unsatisfactory state of occupational health and safety. This study ascertains and evaluates the factors affecting health and safety management in the construction industries in area undergoing fast infrastructure development, Hengyang city. Two categories of construction industry were chosen for the quantitative study for which stratified sampling procedure was applied and simple random sampling was further used to select the key project participants from the various professional groups. In addition to the actual on-site observation questionnaires and interviews, the interviewees, opinions can also be derived. Statistical technique Relative Importance Index (RII) and Microsoft excel software are used to analyze the data, while the Kendall’s coefficient of concordance is used as a measure of agreement of ranking among factors affecting health and safety management. The analysis shows that the RII and the rank of factors affecting health and safety management in construction industry are vary with in the company categories. Health and safety policy, work environment, and health and safety inspection were ranked as the first three important factors affecting health and safety management in construction sites, respectively. Therefore, relevant stakeholders need to consider the establishment of a valuable management system based on local conditions to provide a strong guarantee for the health and safety of workers and sustainability maintenance of construction projects. This study will inspire future works to be done on the role of owners and the development of further guidelines to lessen the accidents in construction sites.

1. Introduction
The success of any construction project is highly depending on health and safety management and its objective is to obtain a clear and successful work on the construction sites without fatalities or injuries among the workers and other administrators on the construction site[1];[2]. The construction industry has got the recognition of being a highly risky industry because of the high rate of accidents and fatalities that happen on construction sites around the world [3]. When compared with other, e.g., labour intensive industries, construction industry has historically experienced a disproportionately high rate of disabling injuries and fatalities for its size [4]; [5].

To regulate procedures and standards relating to construction health and safety management, the Chinese government issued a series of Laws and regulations named construction Law, Production safety Law and Regulation for production safety construction projects [6]. However, although general safety performances have improved in the past few decades, a large number of accidents are still occurring in the country. According to statistical reports released by the Ministry of Housing and
Urban-Rural Development (MOHURD) of china 634 accidents occurred in the Chinese housing and municipal construction industry during 2016 and 692 accidents occurred in 2017 resulting in 735 and 807 deaths, respectively [7]. The numbers of accidents and deaths have thus increased, which shows that safety is still a major issue for the Chinese construction industry. However, health and safety management is an important for the construction industry humanitarian concern needs proper control [8]. [9] described risk control is the process of establishing, evaluating and analyzing expected and possible damage on construction sites and of forming mitigating strategies in order to reduce the risk of damage. The health and safety is obliged to make certain that there are adequate risk controls with respect to health and safety of the workers [10].

As considered by different author’s there are various factors affect health and safety management in the construction industry. These factors may be well known, such as health and safety inspections [11], health and safety management meetings [12], project duration [13], and risk assessment [15]. Though considerable efforts have been made to identify factors affecting health and safety management in construction sector in different parts of the country [6], those research findings have revealed that the factors vary from place to place depending on location-specific aspects. Moreover, there is significant disagreement regarding the extent of influence caused by these factors from site to site and among company categories. Therefore any intervention to address factors affecting health and safety management in construction sector must begin with locally specific understanding of the different factors to maintain powerful health and safety plan for the safety of workers as well as the project. This condition is especially true for Hengyang city of China where fast infrastructure development has been undergoing. Thus, it is vital to determine factors affecting health and safety management in construction industry in this highly developing area. This information would facilitate measures to halt and reverse the situation of health and safety management problems in the construction field and would improve understanding of the influence of various factors on health and safety management.

Considering these, this paper was designed with the following objectives: (i) to explore and identify factors affecting health and safety management in construction industry, (ii) to prioritize the health and safety management determinants in terms of their significance effect, and (iii) to recommend the practical knowledge to be undertaken in health and safety management in construction projects.

2. Materials and Methods

2.1. The study area

Two categories of construction companies were selected for these studies which are found in Hengyang city, China. Hengyang is the second largest city of Hunan province; it straddles the Xiang River about 160 km south of the provincial capital of Changsha and it has an area of 15,279 km² with total population of 7,141,162 (Dec 2010). There are 1,075,516 people in the built-up of 522 km² in the 4 central urban districts (HMBS 2010).
Hengyang is a busy and growing industrial city and the leading transportation center of Hunan province. There are lots of construction works going on in the city which have brought drastic change and also attracted many of workers from the neighboring towns to be hired for skilled as well as unskilled construction workers. These changes have promoted concerns and attempts to consider for the various health and safety management influencing factors in the construction site for a worthy management system to maintain powerful health and safety for the well-being of the workers and for the sustainability of the construction project.

2.2. Sample size
The objective of sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provides a good representation of the population. A sample size of 100 practitioners from the total population of 525 practitioners registered with their professional bodies was determined for the questionnaire survey using the formula proposed by [16] as follows: \( n = \frac{N}{1 + N(e)^2} \), where \( n \) is the sample size, \( N \) is the total population size and \( e \) is the standard error of sampling distribution assumed to be 0.005.

2.3. Data acquisition and processing
For the sake of reliability and validity of the data and to address the formulated objectives the researcher used both primary and secondary data sources. The primary data sources involved field observation focused group discussion, and key informant interview. And as secondary data sources published scientific articles, unpublished documents and reports were used. Face to face interviews were conducted with experienced management staff of companies and other stakeholders to capture their thoughts and suggestions on health and safety management determinants and their sources in china construction industry.

The questionnaire was designed with a composition of two parts: part one: the motive was to establish the perceptions of the key project participants (owners, contractors, sub-contractors, managers and workers) of the critical health and safety management hazards identified in the interview stage. Part two: Includes the list of the factors affecting health and safety management in the construction industry. It contains fifteen (15) representative factors for the study as identified during the literature review. For each factor there are questions, for measuring their degree of impact on health and safety management. The questionnaire was organized in the form of degree of impact as constructed on a five point Likert scale [17] Table 1.
Table 1. Scale and level of factors affecting health and safety management

| Level | Very strong effect | Strong effect | Medium effect | Low effect | Very low effect |
|-------|--------------------|---------------|---------------|------------|----------------|
| Scale | 5                  | 4             | 3             | 2          | 1              |

To determine the relative ranking of the factors, these scores were then transformed to importance indices based on the formula of Relative Importance Index [18].

Relative Importance Index (RII) = \[ \frac{\sum W}{AN} = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + 1n_5}{5N} \]

Where W is the weighting given to each factor by the respondents, ranging from 1 to 5, \( n_1 \) = number of respondents for very low effect, \( n_2 \) = number of respondents for low effect, \( n_3 \) = number of respondents for medium effect, \( n_4 \) = number of respondents for strong effect, \( n_5 \) = number of respondents for very strong effect. A is the highest weight in the study it is 5; and N is the total number of samples. The relative importance index ranges from 0 to 1.

2.4. Data Analysis Method

Two forms of statistical analysis were undertaken: descriptive statistics such as percentages were used to summarize information from respondents. Also inferential statistics such as relative importance index (RII) method was used herein to determine the respondent perceptions of the relative importance of the identified factors affecting health and safety management in the construction industry. Kendall’s coefficient of concordance was used to determine whether there is a significant degree of agreement among the two groups of company’s respondents in ranking factors affecting health and safety management. Kendall’s coefficient of concordance (W) involving the formula \[ W = \frac{12S}{M^2(n-1)n} \] used as a measure of agreement among ranks. The Kendall’s coefficient of concordance (W) indicates the degree of agreement on a 0 to 1 scale. W = 0: indicate no significant degree of agreement among the respondents of the two companies, whereas W = 1 indicates there is a significant degree of agreement among the respondents of the two companies in the ranking process. The interview data was analysis using conceptual content analysis which takes into account the appearance of a concept or the number of times (frequency) a particular concept appears in a text.

3. Results and Discussion

3.1. Analysis of Demographic conditions and Factors affecting Health and Safety Management

To determine the respondents’ socioeconomic character, the variables of demographic character such as; age, gender, level of education, stakeholder’s job title and their working duration were included in the survey questionnaire and conducted the survey at each selected site as shown (Table 2).

Table 2. The demographic characteristics of respondents

| Items         | Descriptions               | Numbers | Percentage |
|---------------|----------------------------|---------|------------|
| Age           | 20-29 years old           | 30      | 60         |
|               | 30-39 years old           | 10      | 20         |
|               | 40-49 years old           | 3       | 6          |
|               | More than 50 years old    | 7       | 14         |
| Gender        | male                      | 46      | 92         |
|               | Female                    | 4       | 8          |
| Qualification | Doctor of philosophy (PHD)| 2       | 4          |
|               | Master of degree          | 1       | 2          |
|               | Bachelor degree           | 20      | 40         |
|               | Diploma                   | 24      | 48         |
Accordingly, the results show among respondents gender 8% of them are female while 92% are male. Concerning the age of the respondents, it varies from lower group accounting 6% of the total for the age group from 40-49 years followed by the above 50 years age group which is 14% and 20% for the age from 30-39. It indicates about 60% of the sampled respondents are young in the age groups of 20-29, showing that the expansion of infrastructure projects are creating good job opportunity for the young age class. Most of the samples attended diploma program (48%) followed by bachelor’s degree (40) and who certificate is 6% followed by doctor of philosophy (4%) and master’s degree (2%).

Furthermore, regarding the composition of the stakeholders from 50 respondents 38% of them are site workers, 20% of them are site engineers, 18% are sub-contractors, 16% are contractors, 4% are site supervisor and 4% are owner. Among respondents working in the construction industry, the results indicated that 42% of them have less than 10 years working duration, 38% have less than 5 years experience and only 20% of them have experience more than 10 years. Exhibited that majority of the workers in these industries have less than experience so that they are exposed to the problem of health and safety management.

The analysis of factors affecting health and safety management in construction industry involved an inferential statistics relative importance index (RII) to determine the respondent perceptions on the relative importance of the identified factors (Table 3):

Table 3. Summary of RII and ranking of factors affecting health and safety management in construction industry

| Factors affecting health and safety management in the construction industry | Virtual UT company RII | Rank | Happy Town company RII | Rank | Over all RII | Rank |
|---|---|---|---|---|---|---|
| Health and safety Inspection | 0.792 | 2 | 0.75 | 8 | 0.771 | 3 |
| Welfare Facilities | 0.723 | 10 | 0.742 | 10 | 0.73 | 12 |
| Health and safety Management Meetings | 0.769 | 4 | 0.75 | 9 | 0.759 | 8 |
| Health and safety Training | 0.761 | 5 | 0.775 | 6 | 0.768 | 5 |
| Risk Assessment | 0.753 | 6 | 0.783 | 5 | 0.768 | 4 |
| Project duration | 0.715 | 12 | 0.808 | 2 | 0.762 | 7 |
| Role of government and engineering societies | 0.723 | 11 | 0.74 | 11 | 0.732 | 11 |
| Work environment | 0.8 | 1 | 0.792 | 4 | 0.796 | 2 |
| Accidents / Incidents / Weather Condition | 0.746 | 7 | 0.758 | 7 | 0.752 | 9 |
| Fire drill | 0.731 | 9 | 0.8 | 3 | 0.765 | 6 |
| Safety signals, signs and barricades | 0.738 | 8 | 0.733 | 12 | 0.735 | 10 |
| Complexity of the Design | 0.71 | 13 | 0.70 | 15 | 0.705 | 14 |
| Type of Owners | 0.562 | 15 | 0.725 | 14 | 0.644 | 15 |
| Health and safety Policy | 0.776 | 3 | 0.817 | 1 | 0.797 | 1 |
As shown in Table 3 the RII was calculated for each category of factors separately and rank was given according to the RII results. It can be found from the results that the most factors affecting health and safety management in the virtual university town company, respectively are work environment ranked in the 1st position with RII=0.80, health and safety inspection is ranked in the 2nd position with RII= 0.792, health and safety policy ranked in the 3rd position with RII= 0.776, health and safety management meeting ranked in the 4th position with RII= 0.769, health and safety training is ranked in the 5th position with RII= 0.761 among others. These showed that the work environment is the most significant factors affecting health and safety management in the infrastructure development of Hengyang city needs more focus for the safety and sustainability of the project in particular and for the health and safety of the workers in the economy followed by other factors.

While, in the happy town company the first most five factors are health and safety policy ranked in the 1st position with RII=0.817, project duration is ranked in the 2nd position with RII=0.808, Fire drill is ranked in the 3rd position with RII= 0.8, work environment is ranked in the 4th position with RII= 0.792 and risk assessment is ranked in the 5th position with RII= 0.783 respectively. These showed that from the two categories of companies the RII and Rank of the factors are varies among the companies categories. As remarked [20] due to different local conditions and different perspectives on management systems the effect of similar management factors might be different.

The calculated RII for all both companies (Table 3), shows that health and safety policy ranked in the 1st position with RII= 0.797, work environment is ranked in the 2nd position with RII=0.796, health and safety inspection is ranked in the 3rd position with RII=0.771, risk assessment is ranked in the 4th position with RII=0.768, health and safety training is ranked in the 5th position with RII =0.768 respectively are the first five dominant factors affecting health and safety management. This reveals that the safety police practiced in the country have certain gap in participating health and safety management that need due attention than other determinants.

3.2. Degree for agreement of ranking on factors affecting health and safety management
In the two categories of company considered many factors as important factors and agreed on the importance of those factors. To determine whether there is a significant degree of agreement among the two groups of companies (Virtual University Town and Happy Town) Kendall’s coefficient of concordance (W) is used as a measure of agreement among rankings. The calculated coefficient concordance was found to be 0.79 (Table 4). This shows that, there is a significant degree of agreement among the factors ranked by the respondents of both categories considered for the study. Therefore, the two groups of companies agree with each other among the ranks of factors affecting health and safety management in construction industry.

| Factors affecting health and safety management in the construction industry | Virtual U.T | Happy Town |
|-----------------------------|-------------|------------|
| Health and safety inspection | 2           | 8          |
| Welfare Facilities          | 10          | 10         |
| Health and safety Management Meetings | 4      | 9          |
| Health and safety Training  | 5           | 6          |
| Risk assessment             | 6           | 5          |
| Project duration            | 12          | 2          |
| Role of government and engineering societies | 11 | 11 |
| Work environment            | 1           | 4          |
| Accidents / Incidents /     | 7           | 7          |
| Weather Condition           | 14          | 13         |
| Evacuation Plan / Fire drill| 9           | 3          |
| Safety signals, signs and barricades | 8       | 12         |
| Complexity of the design    | 13          | 15         |
| Type of Owners              | 15          | 14         |

| Rank | R1   | R'   | R   | S   | W   |
|------|------|------|-----|-----|-----|
| 10   | 16   | 36   | 0.032 |
| 16   | 16   | 0.014 |
| 13   | 16   | 9    | 0.008 |
| 11   | 16   | 25   | 0.022 |
| 11   | 16   | 25   | 0.022 |
| 14   | 16   | 4    | 0.004 |
| 22   | 16   | 36   | 0.032 |
| 5    | 16   | 121  | 0.108 |
| 14   | 16   | 4    | 0.004 |
| 27   | 16   | 121  | 0.108 |
| 12   | 16   | 16   | 0.014 |
| 20   | 16   | 16   | 0.014 |
| 28   | 16   | 144  | 0.128 |
| 29   | 16   | 169  | 0.151 |
4. Conclusion
In this study factors affecting health and safety management in construction industry were signified and prioritized. All of the factors affecting health and safety management are concise in table 3 and their order of significance described in table 4, which is from “very strong effect” to “very low effect”. The analysis showed the ranking of the factors affecting health and safety management are varied within company categories. It can be noticed that health and safety inspection had the second ranking position in the virtual University Town Company, but eighth ranking positions for the Happy Town Company. This indicates that health and safety inspection is well understandable and recognizable by the Companies of virtual University Town and almost had limit usage by happy town company. Further, health and safety management meetings had the fourth ranking positions in the company of virtual university town, but ninth ranking positions for happy town company. This means that health and safety management meetings are essential to maintain the health and safety management in construction industries. The most significant factors (e.g., Health and safety policy; work environment; and Health and safety Inspection) were regarded as the first three very important factors affecting health and safety management, respectively (Table 3) that need due attention to mitigate the problems of health and safety management. Whereas, the factor (Type of Owners) grade as “less important” as indicated in the same table.

Hence, setting proper health and safety management systems based on the local conditions plays an important role in the development of infrastructure projects. Likewise, the health and safety management systems performance needs to be continuously improved with the execution of proper management system. Meanwhile, a set of procedures such as: (i) disseminate and firm the existing health and safety policies for the organization, and then ensure they are carried out; (ii) provide a coordinated control at the same time offering responsibility for all stake holders involving in the construction activities to sustain powerful health and safety plan for the safety of the workers. Furthermore, this study will inspire additional research and the development of further guidelines for health and safety management to avoid or mitigate the accidents in construction sites.

References
[1] Nawaz, T., Ishaq, A., Ikram, A.A. (2013): Trends of Safety performance in construction and civil engineering projects in Pakistan. – Civ. Environ. Res. 3:23-40.
[2] Shao, B., Hu, Z., Liu, Q., Chen, S., He, W. (2019): Fatal accident patterns of building construction activities in China. – Saf. Sci. 111: 253-263.
[3] Smallwood J., Haupt T., Shakantu. (2008): construction health and safety in South Africa: status and recommendations.
[4] Hinze, J., Wiegand, F. (1992): Role of Designers in construction worker safety. - Journal of construction Engineering and Management 118(4): 677-684.
[5] Zhou, X.H., Shen, S.L., Xu, Y.S., Zhou, A.N. (2019): Analysis of production safety in the construction industry of china 2018.- Sustainability 11: 4357.
[6] Zhang, S. L., Yuan, S. (2014): A study on spatial differences of housing and municipal works safety accidents in china and their evolution.- China Saf. Sci. J. 24: 133-137.
[7] Ministry of Housing and Urban- Rural Development of the People’s Republic of China (MOHURD).Safety Standards for Prevention and Control of Construction Accidents, JGJ/T429-2018. Available online: http://www.mohurd.gov.cn/wjfb/201808/t20180821_237293.html (accessed on 14 February 2020). (In Chinese)
[8] Kines, P., Spangenberg, S., Dyreborg, J. (2007): Prioritization occupational injury prevention in the construction industry: Injury severity or absence?.-Journal of safety Research 38 (1): 53-58.
[9] Yin, R. K. (2014): Case study research: Design and methods (5th ed.).-London: Sage.
[10] Panagiostis Chountalas (2017): Implementing an integrated health safety and environmental management system: The case of a construction company.-International Journal for Quality Research 11 (4): 733-752.

[11] Reese, C., 2003. Occupational Health and Safety Management: A practical Approach. 1st ed. S.l.: CRC Press.

[12] Fang, D., Huang, X., Hinze, J. (2004): Benchmarking Studies on construction safety management in China.-Journal of Construction Engineering and Management 130 (3): 424-432.

[13] Zou, P., Zhang, G., Wang, J. (2007): Understanding the key risks in construction project in China.-International Journal of Project Management 25 (6): 601-614.

[14] Nawaz, A., Waqar, A., Shah, S. A. R., Sajid, M., Khalid, M. I. (2019): An innovation framework for risk management in construction projects in developing countries: Evidence from Pakistan.-Risks 7:7-24.

[15] Rocha, M., Searcy, C., Karapetrovic, S. (2007): Integrating sustainable development into existing management systems.-Total Quality Management & Business Excellence 18 (1-2): 83-92.

[16] Yamane, T. (1967): Statistics, an introduction analysis, 2nd ed, New York:-Harper and Row.

[17] Peterson, R. (1999): Constructing Effective Questionnaires.

[18] Enshassi, A., Mohamed, S., Abushaban, S. (2009): “Factors affecting the performance of construction project in the Gaza strip.-J. Civ. Eng. Manag 15:269-280.

[19] Kaming, F. (1996): Project Managers’ Perception of production Problems: An Indonesian Case Study.-Building Research and Information, 24 (5), PP. 302-310.

[20] Almeida, J., Dominguez, P., Sampaio, P. (2014): Different Perspectives on management systems integration.-Total Quality Management & Business Excellence25 (3-4): 338-351.