Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):137-143

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Empirical research on the cognitive risk of scaffolding workers' unsafe behaviors

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ABSTRACT

Safety cognitive risk (SCR), which has aroused extensive concern in recent years, is the subject of many safety management studies. However, studies on the safety cognitive risk of scaffolding workers by questionnaire survey in construction industry remain scarce. The purpose of this study was to verify safety cognitive risk with the aim at scaffolding workers' unsafe behaviors in China. In order to obtain the safety cognitive risk test model, taking working without safety belts and throwing objects from the high as specific examples, the SPSS 17.0 (Statistical Product and Service Solutions) was used to verify safety cognitive risk and analyze influence factors through ANOVA (Analysis of Variance) and T test methods. The results show that the safety cognitive risk is exist, especially evaluating the severity of injuries to others. What's more, influence factors of age and working tenures are not significant in the SCR. The results of this study will provide the improvement consult and management suggestion in safety management of scaffold.

Keywords: Scaffolding workers**;** Unsafe behavior; Underestimated risk; Working tenures; Externality

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INTRODUCTION

Scaffold is widely used in construction that has contributed to great economic and social benefits[1]. But at the same time, affected by environment, quality and other factors, scaffolding job security accidents have become common in building construction[2, 3]. Scaffolding workers play the main role in the scaffolding operations, therefore, from the perspective of human unsafe behaviors, analysis of causes of scaffolding accident is of significant importance in enhancing the level of job security, development of safety control measures[4, 5].

According to many surveys, working without safety belts and throwing objects from the high are the familiar unsafe behaviors to scaffolding workers, which ranked the top 2 among all the accident types[6]. Therefore, in view of the serious consequences of the accidents, in-depth analysis of causes are necessary to set up relevant effective measures.

A lot of causes may lead to unsafe behaviors, one of which is the safety cognitive risk(SCR)[7]. Generally, scaffolding workers will assess the risks of the unsafe behaviors before they decide whether to operate for unwilling to see anyone injured by them no matter themselves or others[8]. But most of the situations, the subjective risk assessment of scaffolding workers are not consistent with the objective risks[9]. And scaffolding workers will be more likely to operate unsafe behaviors once the risks of unsafe behaviors are wrongly underestimated[10].

The cause of safety cognitive risk(SCR), generally explaining, is the lack of safety acknowledge and experience as well as the lack recognition of dangerous results by unsafe behaviors[11]. Therefore, young scaffolding workers with little working tenures will often underestimate risks of unsafe behaviors[12]. In addition, unsafe behavior is of externality so that it will not only threaten the scaffolding workers but also hurt others[13, 14]. However, compared

with the concern about others, the scaffolding workers concerned more about their own profit, thus they often underestimate or even ignore the risks of unsafe behaviors to others[15, 16].

Based on the above causes, the scaffolding workers' risk sensation is taken as a major factor in many studies when analyzing the causes of unsafe behaviors[17]. But few scholars take special study on cognitive risk of scaffolding workers' two unsafe behaviors. Therefore, questionnaires are sent out to gain risk assessment value of scaffolding workers and managers to the two unsafe behaviors, and then take one sample T test method based on managers' risk assessment value to quantitatively verify whether scaffolding workers underestimate risks of unsafe behaviors. Next, variance analysis will be taken to verify whether age and working tenures influence scaffolding workers' risk assessment value. At last, the risk assessment value of the two behaviors will be compared by taking one sample T test method to verify whether scaffolding workers tend to underestimate unsafe behaviors' externality.

1. Risk definition

SCR can be assessed in two aspects: possibility and severity of accidents resulted by unsafe behaviors[18]. The traditional risk evaluation method take the product of possibility and severity as value-at-risk of the behaviors, as a matter of fact, the counting method is not accurate for the different reliance to possibility and severity when scaffolding workers judge risks[19]. Therefore, risk possibility and severity are verified separately.

In addition, when it comes to underestimating risks, there must be a basic value of risks as a comparison. SCR of scaffolding workers exist when scaffolding workers' risk assessment value is lower than basic value. Strictly, the risk basic value should represent the value of objective risks and it can be measured through the frequency of accidents and severity of result actually caused by unsafe behaviors[20]. A large amount of accident data are needed to support this measurement, whereas, present accident information management level is far from the above request in construction industry. Managers' risk assessment value is more objective in comparison with scaffolding workers for managers have more abundant safety knowledge and access to full accident information. Therefore, managers' risk assessment value is chosen as basic value.

2. Research program

2.1 Research hypothesis

To simplify discourse, model parameters are listed in Table. **1**. A combination of different subscripts represents the risk assessment value of different accidents, for example, R_{LWB} represents the workers' total risk assessment value of accident likelihood caused by unsafe behavior without safety belts.

Table. 1 Index definition

Model parameter	Meaning
R	The total risk assessment value
r	The risk assessment value of the investigation samples
L	Likelihood
S	Severity
W	Workers
M	Managers
B	The unsafe behavior without safety belts
H	The unsafe behavior throwing objects from the high

2.2 Research process

In the way of questionnaire start the research which is on risk assessment (possibility and severity) of workers and managers to the two unsafe behaviors. The questionnaire is designed in Likert-Scale[21, 22], and to each unsafe behavior, 5 options on a scale of 1 to 5 are chosen, among which 1 is on behalf of very low value and 5 is on behalf of very high value. The higher the score, the bigger the estimated risk.

2.2.1 Existence of SCR

The average risk assessment value of managers to each unsafe behavior is taken to test whether workers underestimate risks significantly with the help of test method of single sample *T*. The original hypothesis and alternative hypothesis are shown in **Error! Not a valid bookmark self-reference.**. If the original hypothesis is valid, so is the hypothesis that workers underestimate risks.

Table. 2 Hypothesis that workers underestimate externalities of unsafe behaviors

Tested parameters	Original hypothesis	Alternative-hypothesis
R_{LWB}	$R_{\mathrm{LWB}} < \overline{r_{\mathrm{LMB}}}$	$R_{LMB} \geq \overline{r_{LMB}}$
R_{SWB}	$R_{SWB} < \overline{r_{SMB}}$	$R_{SMB} \geq \overline{r_{SMB}}$
R_{LWH}	$R_{\mathrm{LWH}} < \overline{r_{SMH}}$	$R_{LWH} \geq \overline{r_{LMH}}$
R_{SWH}	$R_{SWH} < \overline{r_{SMH}}$	$R_{SMH} \geq \overline{r_{LMH}}$

2.2.2 Influence of age and working tenures on SCR

According to the grouping of age and working tenures in section "Research process", the method ANOVA of single factor is used to test whether significant difference in SCR exists between different age and working tenures.

2.2.3 Externality of SCR

To test whether workers underestimate externalities of unsafe behaviors, the test method of paired sample T is used in the research on the relationship between "the ratio among risk assessment value of workers working without safety belts and risk assessment value of managers" and "the ratio among risk assessment value of workers throwing objects from the high and risk assessment value of managers". The original hypothesis and alternative hypothesis are shown in Table. **3**. If the original hypothesis is valid, so is the hypothesis that workers underestimate externalities of unsafe behaviors.

Table. 3 Hypothesis that workers underestimate externalities of unsafe behaviors

Original hypothesis	Alternative-hypothesis
$\frac{R_{LWB}}{r_{LMB}} - \frac{R_{LWH}}{r_{LMH}} > 0$	$\frac{R_{LWB}}{r_{LMB}} - \frac{R_{LWH}}{r_{LWH}} \leq 0$
$\frac{R_{SWB}}{r_{SMB}} - \frac{R_{SWH}}{r_{SMH}} > 0$	$\frac{R_{LWB}}{r_{LMB}} - \frac{R_{LWH}}{r_{LWH}} \leq 0$

2.3 Test Method

(1)Descriptive statistics analysis: By this analysis, a preliminary understanding of the basic features and characteristics of the sample structure are made after questionnaires. Then, it's used to encode quantified samples data as well as analyze the mean of the various variables and the standard deviation on risk assessment. In the result, the low mean stands for the little risk and the small standard deviation represents the high consistency with the risk assessment of sample.

(2)T-test analysis: T-test analysis is used to test the relationship that the ratio of two unsafe behaviors are equal to determine whether scaffolding workers tend to underestimate unsafe behaviors' externality.

(3)One-way ANOVA: One-way ANOVA is mainly to test whether the risk assessment values of different ages and working tenures are equal and to verify whether there are significant differences in the values in all dimensions of the different samples.

RESULTS AND DISCUSSION

3.1 The sample recovery profile

Apart from the research on risk assessment of workers and managers, personal information of workers is also in the research, including age and working tenures in construction industry and other work area once they experienced.

Table. 4 List of the research sample recovery profile

Research object	Representative number of sampling	Recovered number of samples	Recovery rate	Effective number of samples	The valid recovery rate	Invalid number of samples
Managers	30	27	90.00%	25	92.59%	2
Workers	150	121	80.67%	106	87.60%	15

There are totally 121 scaffolding workers and 27 managers in the research. However, 15 questionnaires of scaffolding workers and 2 questionnaires of managers exist problems that present exactly the same data or lack part of data seriously. As a result, 106 questionnaires of scaffolding workers and 25 questionnaires of managers are effective. The result of data and ratio are shown in

Figure. **1**. Apparently, all the data below have shown that age, working tenures and work area are quite representative, which can reflect the basic situations of scaffolding workers in China.

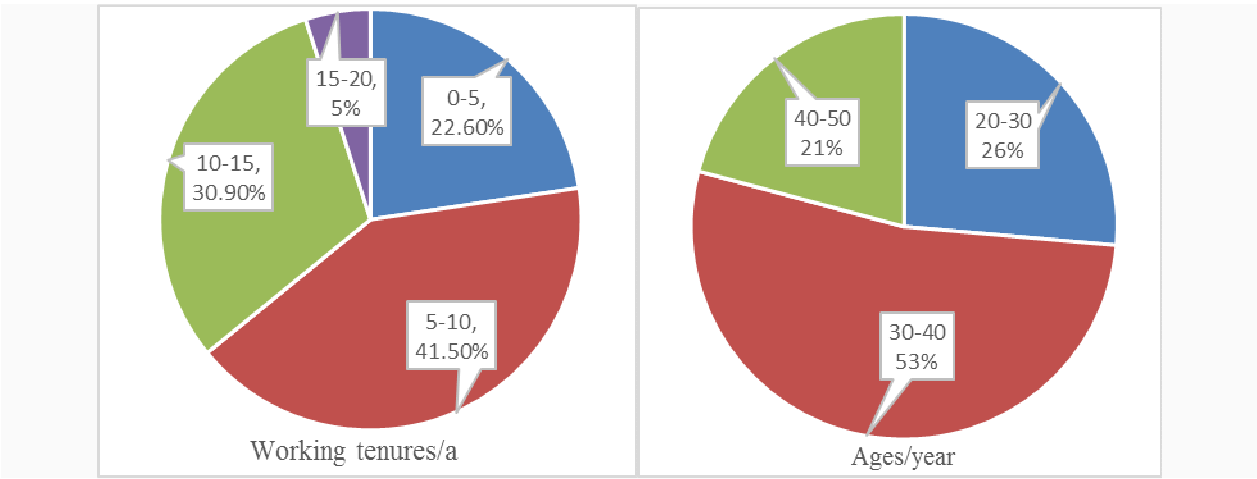

Figure. 1 Characteristics of scaffolding workers

3.2Results of risk assessment

The assessment of workers and managers to possibility and severity of accident caused by the two unsafe behaviors is listed in Table. **5**. From the mean, all the risk assessment values are bigger than 3.00, which show that risks of the two unsafe behaviors were thought to be high by workers and managers. However, standard deviations are commonly large, even more than 1. What's more, the maximum value differs a lot from minimum value, showing that workers and managers have an obvious difference in realizing risks of unsafe behaviors. In addition, the risk assessment values of managers are bigger than that of workers comparing the corresponding risk assessment values.

Table. 5 Risk assessment of workers and managers

Variables	Minimum Values	Maximum Values	Means	Standard deviations
r_{LWB}	1.00	5.00	3.3401	1.0502
r_{SWB}	3.00	5.00	3.9809	0.6901
r_{LWH}	1.00	5.00	3.3402	1.1368
r_{SWH}	3.00	5.00	3.9250	0.6124
r_{LWB}	2.00	5.00	3.7998	1.0016
r_{SWB}	3.00	5.00	4.1897	0.7463
r_{LWH}	2.00	5.00	3.9598	1.0199
r_{SWH}	3.00	5.00	4.3596	0.6375

Table. 6 Test results of underestimation of workers on risks

Variables	Tested Values	T value	Statistical one-tailed Significance	Divided differences
R_{LWB}	$\overline{r_{LMB}}$	-4.5242	0.00	-0.4599
R_{SWB}	$\overline{r_{SMB}}$	-2.6668	0.00	0.1791
R_{LWH}	$\overline{r_{LMH}}$	-5.6155	0.00	-0.6202
R_{SWH}	$\overline{r_{SMH}}$	-7.3189	0.00	-0.4360

3.3 Existence of SCR

The test results of single sample T between risk assessment values of workers and that of managers is given in Table. **6**.As to risk assessment values of the four aspects, statistical significance are less than 0.01 (in the fourth roll) and T value is less than 0 (in the third roll), thus it is reasonable to acknowledge that workers have underestimated risks of unsafe behaviors while the number of significance is 10%.

3.4 The influence of ages and working tenures on risks assessment

3.4.1 The influence of working tenures to risk assessment

Figure. **2** **Risk values of workers with different working tenures on unsafe behaviors** drawn by SPSS is the risks assessment means of scaffolding workers with different working tenures. It is clear that the four kinds of risks assessment values of scaffolding workers with less than five years' working tenures are the lowest; but the more working tenures scaffolding workers possess, not always the bigger risks assessment values.

The statistical verification results given by SPSS suggests that except the other there is statistical significance respectively are 0.090, 0.871 and 0.867, which are all bigger than 0.05. Therefore, at the significant level of 5%, the risk assessments of scaffolding workers with different working tenures are of no difference in the three parts. For R_{LWH} statistical significance is 0.038, which is smaller than 0.5, thus at the level of 5% significance, its' thought that the possibility assessments of scaffolding workers with different working tenures toward accident caused by throwing objects from the high are of difference.

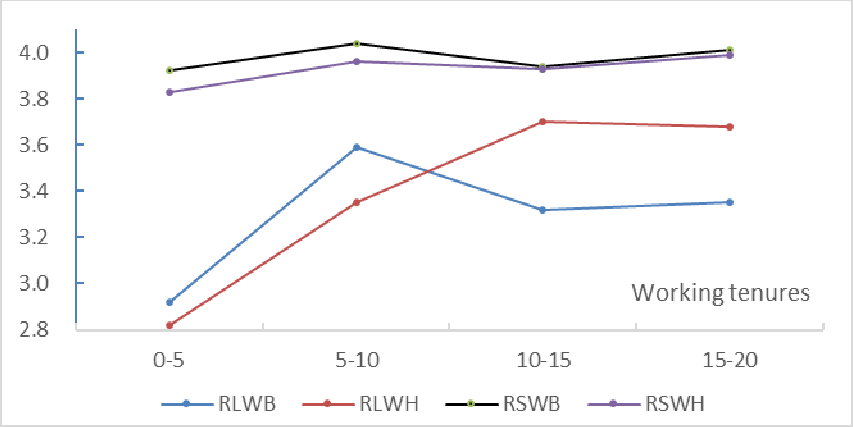

Figure. 2 Risk values of workers with different working tenures on unsafe behaviors

3.4.2 The influence of ages to risk assessment

Figure. **3** drawn by SPSS is the risks assessment means of scaffolding workers with different age levels. It is clear that the risks assessment values of scaffolding workers' ages between 20 and 30 years are not always the lowest, and as for R_{LWB}, R_{SWB}, R_{LWH} the three kinds of risk assessment values, the risk assessment values of scaffolding workers aged between 40 and 50 turn out to be the lowest; as for all four risks assessment values R_{LWB}, R_{SWB}, R_{LWH} and R_{SWH}, the general rule is that the risks assessment values of scaffolding workers between 40 and 50 years old are the highest.

The statistical verification results given by SPSS suggests that the four kinds of statistical significance respectively are 0.860, 0.135, 0.086 and 0.139, which are all bigger than 0.05, thus at the level of 5% significance, the risk assessment of scaffolding workers in different ages are of no difference.

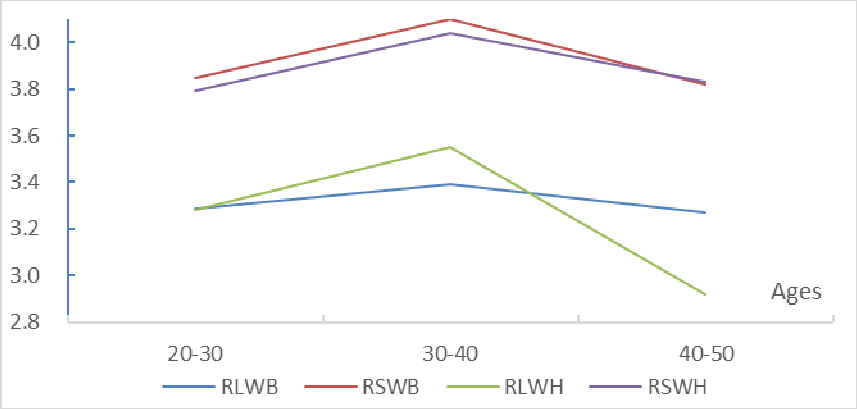

Figure. 3 Risk values of workers with different ages on unsafe behaviors

3.5 Tendency of externality SCR

The test results of paired samples t are as shown in Table. 7. As to possibility, the number of significance is higher than 0.05, therefore, original hypothesis that it is not to be believed workers underestimate severity of accidents that unsafe behaviors may cause to others can be rejected at a significant level of 5%. When it comes to severity, according to statistics, the number of significance is lower than 0.01 but higher than 0, thus the original theory that workers underestimate severity of accidents that unsafe behaviors may cause to others.

Table. 7 Test results of underestimation of workers on external risk

Variables		T values	Statistical Significance-one-tailed
Paired 1	$\frac{R_{LWB}}{r_{LMB}} - \frac{R_{LWH}}{r_{LMH}}$	1.0290	0.1530
Paired 2	$\frac{R_{SWB}}{r_{SMB}} - \frac{R_{SWH}}{r_{SMH}}$	4.1320	0.0000

CONCLUSION

(1) The facts that scaffolding workers underestimate the risks of working without safety belts and throwing objects from the high provided an important foundation for the further study on relationship of underestimation of risks and unsafe behaviors.

(2) The acknowledge that underestimation of risks are more likely to happen among inexperienced young workers is inaccurate, moreover, the underestimation of risks also exists between elder workers with lots of working tenures. Therefore, attention should not be given only to inexperienced young workers, but also given to elder workers.

(3) There exists the problem that the externality of unsafe behaviors are underestimated by workers especially that severity of injury to others caused by their unsafe behaviors. Therefore, the management of unsafe behaviors mainly to cause external risks must be strengthened in safety management. In addition, safety awareness of workers to care about others must also be strengthened.

Acknowledgements

Project supported by the National Natural Science Foundation of China under Grant No. 51379110, and the Science Foundation of China Three Gorges University under Grant No. KJ2013B073.

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