Demographic variables in coal miners’ safety attitude

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Abstract: To change unsafe behavior through adjusting people’s safety attitudes has become an important measure to prevent accidents. Demographic variables, as influential factors of safety attitude, are fundamental and essential for the research. This research does a questionnaire survey among coal mine industry workers, and makes variance analysis and correlation analysis of the results in light of age, length of working years, educational level and experiences of accidents. The results show that the coal miners’ age, length of working years and accident experiences correlate lowly with safety attitudes, and those older coal miners with longer working years have better safety attitude, as coal miners without experiences of accident do. However, educational level has nothing to do with the safety attitude. Therefore, during the process of safety management, coal miners with different demographic characteristics should be put more attention to.

1. Introduction
Mining industry is considered as one of the most dangerous industries in China[1]. Over the past one decade and more, coal mine accidents take a large proportion in industrial accidents. Although China has been improving the level of technology to reduce the accident rates, there is a big gap between China and developed countries in light of mortality of million tons of coal mine. At the same time, studies reveal that 88% of the accidents are caused by human factors [2], while human’s unsafe behavior is the main factor leading to accidents in coal mining industry [3,4]. Only improving the safety technology and facilities can’t reduce the accident rate significantly [5]. How to reduce the occurrence of accidents caused by human factors through various effective ways in order to enhance the safety performance of enterprises has become an urgent problem for scholars in various countries. Lund suggests that accidents can be ultimately prevented by changing behavior through the change of attitudes [9]. Adjusting safety attitudes and thus changing unsafe behavior is an important measure to prevent accidents [6,7,8].

According to the accident proneness theory, some people are more possibly to experience accidents. For employees of different demographic characteristics, the possibility of experiencing accidents is different. Therefore, the research of demographic variables in the field of safety is important and fundamental. Kerlinger also believes that demographic variables have great importance in sociological researches [9]. However, there are few studies of demographic variables, and current studies mainly focus on the aspects such as work stresses [10], leadership behavior [11, 12], and so on. In view of this, we will do research from the perspective of the demographic variables, to study the influence of education, age, length of working years and accident experience on the safety attitudes of coal miners.

2. Research process

2.1. Literature Research and Hypothesis
The impact of demographic variables on safety in different industries has been discussed in the past. Guo Dong-chun finds the demographic characteristics impact on the safety management of highway bridge and tunnel construction teams, and thus established a safety management model. Gao Guoping points out that the staff with higher education have more mature safety attitudes. Bu Meng-meng points out that age, driving years and educational level affect drivers’ awareness of risk. And a man with longer driving years and higher educational level has higher level of risk awareness. In manufacturing enterprises, the employees’ safety attitudes are getting better with the increase of their ages. The safety attitudes of the employees with college or higher academic qualifications are obviously higher than that of employees who have the junior education. The longer their working years are, the stronger their safety awareness is, and thus they have better safety attitudes. In construction industry, Siu suggests that age has an impact on the safety attitude of construction workers, and the results show that the older the construction workers are, the more positive attitudes of safety they have. There are other researches about coal miners suggest that the employees’ age, length of working years and other variables have impact on their intentions of unsafe behavior. Therefore, this paper proposes the following hypotheses:

H1: Educational level influences the safety attitudes of coal miners, and those with higher academic qualifications have better safety attitudes than those less educated.

H2: Age influences the safety attitudes of coal miners, and older coal miner workers have better safety attitudes than younger ones.

H3: Length of working years influences the safety attitudes of coal miners, and senior workers have better safety attitudes.

The study of demographic variables reveals that variables such as age, working years and educational level are the demographic variables which are of great concern to the researchers, and few studies have been done of the accident experiences. Some scholars research the chemical industry, and point out that the safety attitudes can be affected by the frequency that accidents happen. Therefore, this study will also take into account the influence of the accident experiences on the safety attitude of coal miners, and propose the following hypothesis:

H4: Accident experiences influence the safety attitudes of coal miners, and those who have accident experiences have better safety attitudes.

2.2. Research methods
This research uses literature research, questionnaires, and data analysis to study the relationship between demographic variables and safety attitude. We analyze the demographic variables that affect the safety attitudes of different industries, and explore variables that may influence the safety attitudes of coal miners in demographic variables. The safety attitudes and demographic data of the workers are obtained from the questionnaires of safety attitude measurement. We employ SPSS22.0 to do single factor variance analysis and independent sample t-test to analyze the influence of these factors on the safety attitudes.

2.3. Research tool
The demographic variables and safety attitudes of coal miners are studied in the form of questionnaires. The safety attitude measurement questionnaire used in this study are based on Cox and Donald’s study, and the safety attitude questionnaire of coal miners initially developed by Liu Jia-long. The questionnaire includes four dimensions: safety commitment of managers, work pressure, team safety atmosphere, fatalism, and has 17 items. As to demographic variables, this paper mainly investigates the four aspects: age, working years, educational level and accident experiences.

3. Data analysis
808 questionnaires were distributed and 808 questionnaires were given back. After eliminating the invalid questionnaires, 593 effective questionnaires were left, and the effective rate is 73.4%. The demographic information is shown in Table 1.
Table 1. The demographic information of the sample

| Statistics                  | Number | Percentage (%) |
|-----------------------------|--------|----------------|
| **Age**                     |        |                |
| 21~30 years old             | 337    | 58.6           |
| 31~40 years old             | 149    | 25.9           |
| 41~50 years old             | 78     | 13.6           |
| 51~60 years old             | 11     | 1.9            |
| 1~2 years                   | 109    | 18.5           |
| 3~4 years                   | 204    | 34.7           |
| 5~6 years                   | 128    | 21.8           |
| Seven years and above       | 147    | 25.0           |
| Primary school              | 6      | 1.0            |
| Junior high school          | 114    | 19.2           |
| High school or secondary    | 231    | 39.0           |
| University or college       | 216    | 36.4           |
| **Length of working years** |        |                |
| 1~2 years                   | 109    | 18.5           |
| 3~4 years                   | 204    | 34.7           |
| 5~6 years                   | 128    | 21.8           |
| Seven years and above       | 147    | 25.0           |
| **Educational level**       |        |                |
| Primary school              | 6      | 1.0            |
| Junior high school          | 114    | 19.2           |
| High school or secondary    | 231    | 39.0           |
| University or college       | 216    | 36.4           |
| **Accident experiences**    |        |                |
| Without                     | 102    | 17.2           |
| With                        | 411    | 69.3           |

3.1. Reliability and validity analysis
The Cronbach’s α is analyzed by doing exploratory factor analysis with the help of SPSS 22.0. The results are shown in Table 2.

Table 2. The reliability test of safety attitude scale

| Items                      | Cronbach’s α | Items number |
|----------------------------|--------------|--------------|
| fatalism                   | 0.929        | 4            |
| safety commitment of managers | 0.778    | 5            |
| work pressure,              | 0.764        | 4            |
| team safety atmosphere,     | 0.642        | 4            |
| Total questionnaire         | 0.872        | 21           |

Generally speaking, the internal consistency of the questionnaire reliability is insufficient when Cronbach’s α is not more than 0.6. The results show that the value of total questionnaire’s Cronbach's α is 0.872, and each dimension’s Cronbach's α is 0.642−0.929, each one is not less than 0.6, which is acceptable. Based on the exploratory factor analysis, a formal questionnaire was developed to measure coal miners’ safety attitudes. The next step was to perform a confirmatory factor analysis (CFA) to validate the questionnaire by analyzing χ² / d.f., GFI, AGFI, TLI, CFI, RMSEA structural models. CFA is shown in Table 3, the measurement models all reach the requirements of the ideal model and are of a good degree of fit. In summary, the safety attitude questionnaire has good validity and reliability, and can effectively measure the safety attitudes of coal miners, which is the prerequisite for later rational research.

Table 3. Confirmatory factor analysis

| Structural model | χ² / d.f. | GFI  | AGFI | TLI  | CFI  | RMSEA |
|------------------|-----------|------|------|------|------|-------|
| Ideal model      | <3        | >0.90| >0.90| ≥0.95| ≥0.95| <0.08 |
| Measurement model| 2.86      | 0.93 | 0.91 | 0.95 | 0.96 | 0.06  |

3.2. An Analysis of the Relativity between Demographic Variables and Safety Attitudes
As the demographic variables in the age, working years, and educational level are divided into more than two different groups, and variance analysis should be used to analyze the differences in safety attitudes held by different groups, and then conduct Post hoc analysis on the dimensions where differences exist to find the differences between the groups. Finally, the correlation intensity is analyzed between the various dimensions and safety attitudes. The accident experiences are divided into two...
groups, workers with accident experiences and without accident experiences, and they are tested by independent sample t-test.

3.2.1. The Influence of Educational Level on Safety Attitude. From Table 4, we can see that the overall test F value of academic record is 2.387, P value is 0.061 (>0.05), not reaching the significant level. It means that there is no correlation between educational level and safety attitudes, i.e. there is no difference among coal miners of different educational level. It is different from the assumption in H1 that educational level influences the safety attitudes of coal miners, and those with higher educational level have better safety attitudes. As a result, H1 is not supported.

| Variable                  | F-value | P-value |
|---------------------------|---------|---------|
| Age                       | 4.286   | 0.03    |
| Length of working years   | 2.914   | 0.00    |
| Educational level         | 2.387   | 0.061   |

3.2.2. The Influence of Age on Safety Attitude. The P-value of age is 0.03, less than 0.05 (as shown in Table 4), reaching a significant level. However, the variance analysis F statistic belongs to the whole test, when the value of F is significant, it only means that there are at least two groups have difference between the mean value of the dependent variables. To identify the two groups that are different in the average of independent variable, post hoc analysis is still required. Using Tamhane's T2 method, we find that the mean difference in safety attitudes between group 1 and group 3 is -4.53032 (* indicates significance). The results showed that the safety attitudes are different between age groups of 21 ~ 30 and 41 ~ 50. The safety attitude level of 41 ~ 50 age group is higher than 21 ~ 30 age group. The specific results are shown in Table 5.

| (1) age groups | (J) age groups | Average difference (1-J) | Significance |
|----------------|----------------|--------------------------|--------------|
| 21~30          | 31~40          | -1.52120                 | 0.596        |
| 21~30          | 41~50          | -4.53032*                | 0.016        |
| 51~60          | 21~30          | 1.52120                  | 0.596        |
| 41~50          | 31~40          | -3.00912                 | 0.337        |
| 51~60          | 41~50          | 2.84869                  | 0.981        |
| 51~60          | 21~30          | 4.53032*                 | 0.016        |
| 51~60          | 31~40          | 3.00912                  | 0.337        |
| 51~60          | 51~60          | 5.85781                  | 0.684        |
| 51~60          | 21~30          | 1.32749                  | 1.000        |
| 51~60          | 41~50          | -1.32749                 | 1.000        |
| 51~60          | 41~50          | -2.84869                 | 0.981        |
| 51~60          | 51~60          | -5.85781                 | 0.684        |

Wu Ming-Long[22] points out that the dependent variable significance generalized from variance analysis is statistical significance, to analyze the actual significance need to find the correlation strength $\omega^2$. If $\omega^2<0.059$, then the independent variables and dependent variables are in low correlation; if $\omega^2>0.138$, then the independent variables and dependent variables are in high correlation; if $\omega^2$ is between 0.059 and 0.138, then the independent variables and dependent variables are in moderate correlation.

The age group is selected as the dependent variable and the safety attitude as the dependent variable. The single factor procedure is used to determine the association degree of the age group with the safety attitude according to the correlation intensity $\omega^2$. The results are shown in Table 6. The results show that the correlation intensity $\omega^2 = 0.017$ (the adjusted $R^2$ value), which means that age and safety attitudes are in low correlation. The results show that the average scores of safety attitudes of the four age groups are
60.4184,61.9396,64.9487,59.0090, which mean that the safety attitude of employees aged 20-50 are improved with the increase of age. H2 is supported.

Table 6. The effect test of age and safety attitude

| source               | SS     | MS      | F-test | Significance | η²      | Observation of the inspection ability |
|----------------------|--------|---------|--------|--------------|---------|---------------------------------------|
| Corrected mode       | 1409.032 | 469.677 | 4.286  | 0.005        | 0.022   | 0.864                                 |
| Intercept            | 535337.797 | 535337.797 | 4885.127 | 0.000        | 0.895   | 1.000                                 |
| Age                  | 1409.032 | 469.677 | 4.286  | 0.005        | 0.022   | 0.864                                 |
| Error                | 62573.166 | 109.585 |        |              |         |                                       |
| Sum                  | 2231832 |         |        |              |         |                                       |
| The total number after correction | 63982.198 |         |        |              |         |                                       |

- a. $R^2=0.022$ (adjusted $R^2=0.017$)
- b. alpha=0.05

3.2.3. The influence of Working Years on Safety Attitude. The P-value of the working years is 0.00, less than 0.05 (as shown in Table 4), reaching a significant level. The post hoc analysis shows that only the first and fourth groups have difference in safety attitudes, the difference of safety attitudes is only 3.87899. It indicates that the safety attitudes of coal miners of 7 working years and more are higher than the safety attitudes of workers of 1-2 working years. The specific results are shown in Table 7.

Table 7. The post hoc analysis of different working years’ safety attitude

| (I) age groups | (J) age groups | Average difference (I-J) |
|----------------|----------------|-------------------------|
| 1-2            | 3-4            | -2.54425                |
| 1-2            | 5-6            | -2.67661                |
| 1-2            | 7 and above    | -3.87899*               |
| 3-4            | 5-6            | -0.13235                |
| 3-4            | 7 and above    | -1.33473                |
| 5-6            | 1-2            | 2.67661                 |
| 5-6            | 3-4            | 0.13235                 |
| 5-6            | 7 and above    | -1.20238*               |
| 7 and above    | 1-2            | 3.87899*                |
| 7 and above    | 5-6            | 1.33473                 |
| 7 and above    | 7 and above    | 1.20238                 |

The degree of association of the age group with the safety attitudes is judged by the correlation intensity $\omega^2$. The results of the analysis are shown in Table 8. $\omega^2 = 0.010$, the length of working years explains 1% variance of safety attitudes, and the length of working years and safety attitudes are in low correlation. At the same time the statistical results show that the average safety attitudes of the four groups of coal miners are: 59.0734, 61.6176, 61.7500, 62.9524. This shows that the longer the working years are, the better the safety attitudes people have. Coal miners of 7 and more working years have the highest safety attitudes, and coal miners of 1-2 working years have the lowest. Therefore, the assumption in H3 that the length of working years has an impact on the safety attitude of coal miners, and the safety attitudes of long service coal miners are better than the short-term coal miners is supported.

Table 8. The effect test of working years and safety attitude

| source | SS | df | MS | F-test | Significance | η² | Observation of the |
|--------|----|----|----|--------|--------------|----|---------------------|
|        |    |    |    |        |              |    |                     |
3.2.4. The Influence of Accident Experiences on Safety Attitude. The coal miners' accident experiences of this research are divided into two groups: with and without accident experiences, using independent samples t test for analysis. As shown in Table 9, the safety attitude F test value is 0.106 (P = 0.745 > 0.05), t = 2.049 (P = 0.041 < 0.05). There is a difference in the safety attitudes of workers with accident experiences and workers without accident experiences.

| Safety attitude | Equal variance | Equal variance not assumed |
|-----------------|----------------|----------------------------|
|                | F Significance | T Df | Mean Difference | Std. Error Difference | 95% confidence interval of the difference Lower | Upper |
| Safety attitude | 0.106 0.745 2.049 511 | 0.041 2.423 1.182 0.100 | 4.745 |
| Sum of squares  | 64308.256 584 | 110.117 |
| The total number after correction | 65270.957 587 |
| a. R²=0.015 (adjusted R²=0.010) | b. alpha=0.05 |

To analyze the actual salience, we also need to find out the effect value. The effect value representing the total variance of the dependent variable can be explained by the grouping variable. If the effect value is less than or equal to 0.06, it means that there is a low correlation between the grouping variable and the test variable. If the value is more than or equal to 0.14, they are highly correlated. If the effect variable is between 0.06 and 0.14, they are moderate correlated. In this research, η² = 0.008 <0.06 (as shown in Table 10). It indicates a low correlation between safety attitudes and accident experience. Therefore, the assumption in H4 that accident experiences have an impact on the safety attitudes of coal miners is supported. At the same time, the statistical results show that the average safety attitudes of coal miners with or without accident experiences are 61.16 and 63.58, which mean that coal miners who have not experienced accidents have better safety attitudes, so the assumption in H4 that workers with accident experiences have better safety attitudes than those without accident experiences is not supported.
Table 10. The effect test of accident experiences and safety attitude

| Source                    | Sum of class III squares | df  | Mean square | F     | Significance | Local Eta Square | Non-central parameter | Observation of the inspection ability |
|---------------------------|--------------------------|-----|-------------|-------|--------------|-------------------|------------------------|---------------------------------------|
| Corrected mode            | 479.655$^a$              | 1   | 479.655     | 4.200 | 0.041        | 0.008             | 4.200                  | 0.534                                 |
| Intercept                 | 1271438.52               | 4   | 1271438.5   | 11133.6 | 0.000        | 0.956             | 11133.68               | 4                                     | 1.000                                 |
| Accident experiences      | 479.655                  | 1   | 479.655     | 4.200 | 0.041        | 0.008             | 4.200                  | 0.534                                 |
| Error Sum                 | 58354.907                | 511 | 114.197     |       |              |                   |                        |                                       |
| The total number after correction | 58834.561               | 512 |              |       |              |                   |                        |                                       |

a. $R^2 = .008$ (adjusted $R^2 = 0.006$)

4. Conclusion and Outlook

The quantitative relationship between demographic variables and safety attitudes is examined in 593 samples of coal miners, and the results confirm that the correlations between coal miners’ safety attitudes and demographic variables like age, length of working years, and accident experiences are consistent with the assumptions. In addition, this paper also finds a different conclusion from the research hypothesis: educational level has nothing to do with the safety attitudes of coal miners. The reason is that the middle-aged and experienced coal workers’ educational level is generally low in the early career, but long-term work experience makes them have a stronger sense of safety, highly educated people have fluke mind or are lack of experience, which affect their safety attitudes. The accident experiences have a low correlation with the safety attitudes of the workers, but the employees who have accident experiences have lower safety attitudes than those who do not have accidents. The accidents have negative effects on employees’ psychology and ideology and influence badly on their work. They doubt whether the safety of their work can be guaranteed, so the level of safety attitudes is reduced.

This paper also has a strong practical significance. Through the research conclusion, we can find that the safety attitudes of workers who are young, of short working years and have accident experiences are low. If managers are aware of this, then they should attach more importance to certain areas, to strengthen the guidance and training of these employees, and to reduce the loss due to the problems of the working places as much as possible. The research also finds that the level of education is not associated with safety attitude and therefore employees should not be discriminated against during the training in safety education.

At present, the studies of the impact of demographic variables on the safety attitude of coal miners are rather less. Future researches can expand the scope of data investigation, increase the number of people surveyed, use other scientific methods other than questionnaire method to analyze more demographic variables and enhance the universality of research results, which will have a significant impact on the safety development of the coal industry.

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