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Study on the Unsafe Acts and Education Function in Coal Mine Accidents Caused by Rescue

Jiang Wei

China University of Mining & Technology (Beijing), CHINA

Zhu Zhi-Ming

China University of Mining & Technology (Beijing), CHINA

Xiang Yuan-Chi

China University of Mining & Technology (Beijing), CHINA

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ABSTRACT

This paper selects 69 coal mine rescue accidents from 1981 to 2011 in China, focusing on direct unsafe acts and high-frequency unsafe acts that lead to coal mine rescue accidents. Two conclusions can be drawn. The first conclusion is that there are five categories of direct unsafe acts that cause coal mine rescue accidents: not wearing respirators as required, not following the gas detection requirements, the poor abilities of the ambulance crew, technical measures not in place, and the violation of commanding. The first two has a larger proportion, as their sum is 57.97%, more than half. The second conclusion is that out of all relevant unsafe acts, nineteen categories of high-frequency unsafe acts are statistically significant, and 5 types are well-marked due to their higher frequency: not wearing respirators when rescuing, talking through respirator in the underground rescue process, not testing underground gas composition dynamically, not carrying a spare respirator, no pro-examination of the equipment. The analysis results can be used to educate employees and students.

Keywords: education, accidents caused by rescue, unsafe acts, analysis

INTRODUCTION

Coal mine accidents caused by rescue can be classified as objective factors and subjective factors. Objective factors include outdated rescue techniques and equipment. Subjective human factors include more things, such as the commanding errors of the ambulance officers, the violation of commanding, adventurous commanding, improper organization of the rescue operation, physical fitness and psychological quality of ambulance personnel not being strong, etc. Subjective human factors are the main cause of the coal mine accidents.

Foreign researches of mine rescue are in favor of mine rescue mechanism and its management system as well as decision support system research and development of mine rescue operations. Scholars prefer rescue system and rescue techniques in China. Few of them take "accident" as the entry point of analysis, and apply the results for education.

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Correspondence: Jiang Wei, Lecturer, *Faculty of Resources & Safety Engineering, China University of Mining & Technology (Beijing), Ding No. 11 College Road, Haidian District, Beijing, Postal code 100083, China*

Tel: +86-13426323576.

✉ jiangwei678@126.com

State of the literature

- Unsafe acts are not carefully classified.
- There is no systematic summary of unsafe acts caused by coal mine rescue accidents.
- Coal mine rescue accident training is not targeted.

Contribution of this paper to the literature

- Refined the types of unsafe acts.
- Five kinds of direct unsafe actions were brought into the coal mine rescue accidents.
- The results show that 19 kinds of high frequency unsafe acts that cause rescue accidents in coal mines should be strengthened, and education and training should be strengthened.

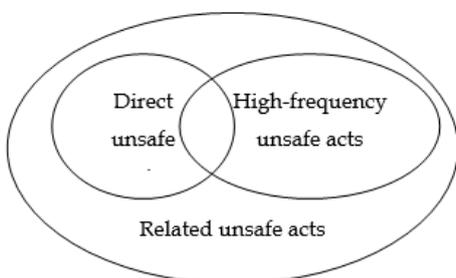


Figure 1. Relationship among direct, related and high-frequency unsafe acts

Therefore, this paper analyzes unsafe acts in coal mine accidents caused by rescue. In the analysis of unsafe acts, direct unsafe acts, which cause these accidents, are stripped out firstly. The categories of direct unsafe acts and specific acts are the focus of analysis. When analyzing related unsafe acts, all unsafe acts are divided and analyzed according to different mechanisms, finding out the high-frequency unsafe acts to provide evidence for the prevention of coal mine accidents caused by rescue. Not only companies can use the research results of unsafe actions to educate employees but also schools can use the results to educate students.

EXPLANATION OF THE CONCEPT OF UNSAFE ACTS

To make the acts of coal mine accidents caused by rescue clear, three concepts in this article relates to unsafe acts; namely: direct unsafe acts, related unsafe acts and high-frequency unsafe acts. Their relationship is as shown in **Figure 1**.

Direct unsafe act of coal mine accidents caused by rescue is the act that cause the accident. A distinctive feature of this act is that it directly causes the accident.

Related acts include both direct unsafe acts that cause the mine rescue accident, but also incentive or unsafe acts that may influence the following evolution of the accident.

High-frequency unsafe acts are those related to unsafe acts with statistical significance. Although these acts don't directly cause the accident, they do have important influence on the occurrence of the accident and its development.

Therefore, this paper focuses on the direct unsafe acts and high-frequency unsafe acts of coal mine accidents caused by rescue.

PRELIMINARY STATISTICS OF UNSAFE ACTS

This paper selects 69 mine rescue accidents from 1981 to 2011 in China, whose level are major, serious or catastrophic (general accidents are not considered). These accidents cover a wide array of different occurrence types

Table 1. Statistical Table of Unsafe Acts in Coal Mine Rescue Accident

No	Type	Specific Form	Number of Times	Proportion
1	Not wearing respirators as required	Not wearing respirators when rescuing	11	16.9%
		Talking through respirator in the underground rescue	8	12.3%
		Removing the respirator without authorization	7	10.7%
2	Not following the gas detection requirements	Not detecting gas in ambulance space before working	9	13.9%
		Not detecting underground gas components dynamically as required	5	7.7%
3	Poor abilities of the ambulance crew	Inability to carry out self and mutual aid in emergency	4	6.2%
		Not carrying rescue equipment like resuscitator	6	9.2%
4	Technical measures not in place	Taking wrong coal mine rescue measures when the underground situation is unclear	5	7.7%
5	Violation of commanding	Forcing rescuers to break into the pit with unknown details	6	9.2%
		Forcing rescuers to work with the awareness of bad rescue condition	4	6.2%

of mine rescue accidents, such as gas explosions, flooding, fire, etc. They also include a wide array of state-owned key coal mines, state-owned local coal mines and township coal mines. Besides, the development of coal mine rescue technology in this period is relatively stable.

By analyzing the acts in 69 coal mine rescue accidents in the sample library, the statistical results of direct acts are given in [Table 1](#).

[Table 1](#) shows that direct unsafe acts of mine rescue accidents have five categories: not wearing respirators as required, not following gas detection requirements, poor abilities of the ambulance crew, technical measures not in place, and violation of commanding. The percentage data in [Table 1](#) is the percentage of direct unsafe actions in the sample, which accounts for the frequency of the direct unsafe actions.

- (1) **Not wearing respirators as required.** Respirator is one of the most important protective tools for rescue crew when conducting underground mine rescue. It can guarantee not only the rescuers' work when rescuing trapped people, but can also be the important barrier for rescuers themselves. It can be found by analysis that not wearing respirators as required have three specific forms: not wearing respirators when rescuing (16.9%), talking through respirator in the underground rescue (12.3%), removing the respirator without authorization (10.7%).
- (2) **Not following the gas detection requirements.** Usually when an accident occurs in the mine, it will affect the normal operation of the ventilation system, and local underground harmful gases will exceed their normal levels because of gas explosion or fire. If rescuers work underground without proper gas detection, this may cause a second explosion or other injuries, which can lead to further accidents. There are two main concrete manifestations by statistics: not detecting gas in ambulance space before working (13.9%), not detecting underground gas components dynamically as required (7.7%).
- (3) **Poor abilities of the ambulance crew.** It has multiple forms, embodied in the lack of mine rescue common sense, can't start rescue work expertly, not skilled in using rescue equipment, significant blunt errors due to nervousness of emergency, etc. Since rescuer is one of the most important participants in mine rescue, their ability directly influences the smooth and orderly conduct. There are two main concrete manifestations by statistics: unable to carry out self and mutual aid in emergency because they don't know how to use rescue equipment, not carrying rescue equipment like resuscitator. Among

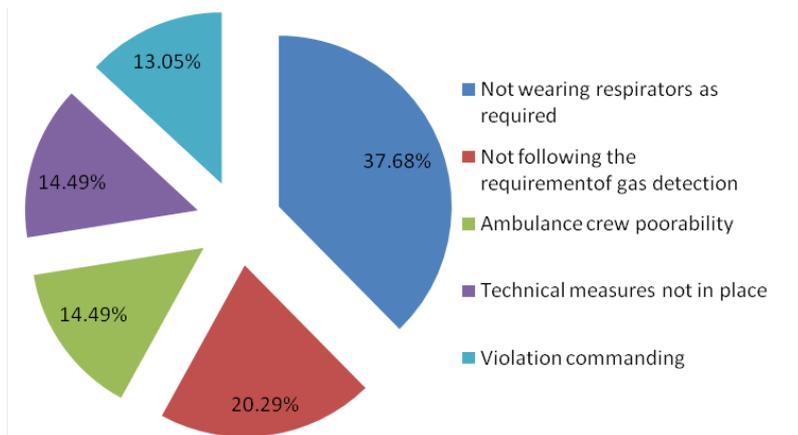


Figure 2. Proportion of different direct unsafe acts (The figures in picture are percentages)

these accidents, four of them (6.2%) happened because the rescuers could not carry out self and mutual aid in emergency and 6 accidents (9.2%) happened because the rescuers did not carry rescue equipment like resuscitator.

- (4) **Technical measures not in place.** Technical measures in mine rescue will directly affect the effectiveness of the rescue operation. Rescue in coal mine accidents is relatively complex and the risk is relatively high. Specific circumstances of different accident types and different environmental factors often lead to different levels of complexity. Therefore, making practical technical measures is vital. There are two main concrete manifestations by statistics: taking wrong coal mine rescue measures when the underground situation is unclear, not making safety rescue and protection measures by rule. The former led to 5 accidents making up 7.7% of the total samples.
- (5) **Violation of commanding.** It is for the commanders in coal mine rescue. After the accident, disaster relief command system must be set up immediately to take charge of the site guidance and scheduling according to "mine rescue procedures". Command system is the instruction giver of a mine rescue team, whose decision and command have direct impact on mine rescue team's action. Violation of commanding can lead to the occurrence of coal mine rescue accidents, or cause disorder and affect the mine rescue process. There are two main concrete manifestation by statistics: forcing rescuers to break into the pit with unknown details, forcing rescuers to work with the awareness of bad rescue condition. Among them, the former caused 6 accidents (9.2%) and the latter caused 4 accidents (6.2%).

Figure 2 shows that there is a big difference in the proportion between 5 unsafe acts of coal mine rescue accidents. Not wearing respirators as required accounts for the largest proportion for 37.68%, and not following the gas detection requirements comes the second, which accounts for 20.29%. The poor ability of the ambulance crew and technical measures not in place accounts for third at 14.49%. The last one is violation of commanding whose proportion is 13.04%. The first two has a larger proportion, as their sum is 57.97%, more than half. Therefore, in the five categories of direct unsafe acts, the focus of prevention and control should be on not wearing respirators as required and not following the gas detection requirements. It can greatly reduce the rate of mine rescue accidents from occurring if these two factors can be controlled well.

Among the specific direct unsafe acts, there are 6 factors in the front rank: not wearing respirators as required (15.94%), not detecting gas in ambulance space before working (13.04%), talking through respirator (11.59%), removing the respirator without authorization (10.14%), not carrying rescue equipment like resuscitator (9.2%) and forcing rescuers to break into the pit with unknown details (9.2%). The sum of six direct unsafe acts of coal mine rescue accidents accounts for 69.11% of all samples. So, these six factors are the main points of controlling concrete behaviors to effectively prevent coal mine rescue accidents.

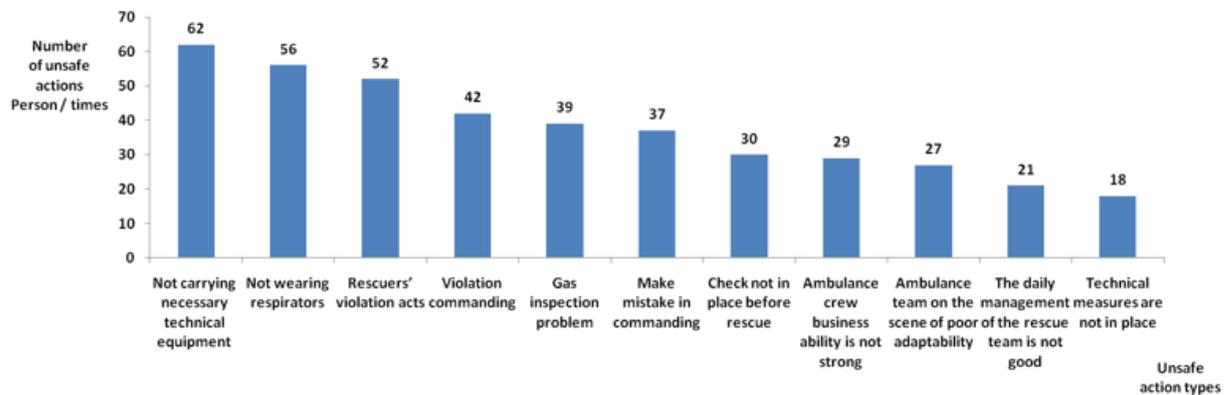


Figure 3. Distribution of different types of unsafe acts

DISCUSSION

Statistics of unsafe acts in this section are one-time acts in every coal mine rescue accident. This means that these are all unsafe acts relevant to the accident. All direct unsafe acts and relevant unsafe acts that lead to an accident are contained.

In order to facilitate the analysis of coal mine rescue accidents, we need to do some induction and consolidation. On the basis of reading abundant coal mine accident cases, using the statistical methods in the last section, related unsafe acts of coal mine rescue accidents are divided into 11 categories: not wearing respirators as required, not carrying necessary technical equipment, not detecting gas as required, poor ability of rescuers, technical measures not in place, pro-examination not in place, violation of commanding, daily management of rescue team not in place, rescuers' acts of violation, poor emergency capability, commanding error. These unsafe acts can be subdivided into 72 categories, which cannot be enumerated due to limited space.

Figure 3 shows that there is a frequency distribution among these types: (1) not carrying necessary technical equipment appears most with 62 people / time (14.87%), (2) not wearing respirators as required with 56 people / time (13.42%), (3) rescuers' acts of violation with 52 people / time (12.47%), (4) violation of commanding with 42 people / time (10.07%). These four types of unsafe acts are the highest-frequency ones with their sum equaling 50.83%, others appear relatively less.

This section calculates 19 categories of high frequency unsafe acts on the basis of 72 relevant unsafe acts in the last section, making it more targeted for controlling and preventing coal mine rescue accidents.

Statistics of high frequency unsafe acts can show which has higher frequency related to accidents. It provides some evidence for later safety training, as well as prevention and control of rescue accidents.

According to the above statistics, top 5 specific high-frequency unsafe acts are: not wearing respirators when rescuing, talking through respirator in the underground rescue process, not testing underground gas composition dynamically, not carrying spare respirator, no pro-examination of equipment. The 19 key statistics of high-frequency unsafe acts are the point of controlling and preventing coal mine rescue accidents, and the 5 high-frequency unsafe acts are the priority among the priorities listed in **Table 2**.

Table 2. High-frequency Unsafe Acts Causing Coal Mine Rescue Accident

No.	Specific Form	Number of Times
1	Not wearing respirators when rescuing	18
2	Talking by mouth breathing when downhole rescuing	17
3	Not detecting underground gas components dynamically as required	16
4	Not carrying spare respirator	14
5	No pro-examination of equipment	14
6	Not bringing disaster-phone	13
7	Going down to rescue with less than six people	13
8	Removing the respirator without authorization	12
9	Not carrying lighting equipment	11
10	Not detecting gas in ambulance space before working	11
11	Forcing rescuers to break into the pit with unknown details	11
12	Lack of on-site emergency response capacity, shouting after mouth appliance off	10
13	Taking off the mouth appliance when resting in disaster area	9
14	No inspection and inquiry about physical conditions of the ambulance crew before working	9
15	Untimely establishment of the repair headquarters, multiple and confusing commanding	9
16	Not letting someone check the gas in the closed downwind side	8
17	No checking one by one according to the fire zone unsealed plan	8
18	Forcing rescuers to work with the awareness of bad rescue condition	8
19	Working alone, unable to see the distress signal	8

CONCLUSION

Following conclusions have been drawn:

- (1) In order to make the acts that lead to coal mine rescue accidents clearer, we classified the concepts of unsafe acts; namely: direct unsafe acts, relevant unsafe acts and high-frequency unsafe acts.
- (2) There are five categories of direct unsafe acts which cause coal mine rescue accidents: not wearing respirators as required, not following the gas detection requirements, the poor abilities of the ambulance crew, technical measures not in place, and the violation of commanding.
- (3) There is a big difference in the proportion between 5 direct unsafe acts of coal mine rescue accidents. Not wearing respirators as required accounts for the largest proportion. Not following the gas detection requirements comes the second. Poor abilities of the ambulance crew and technical measures not in place tie for third, and the last one is the violation of commanding. The first two has a larger proportion, as their sum is 57.97%, more than half.
- (4) Out of all relevant unsafe acts, nineteen categories of high-frequency unsafe acts are statistically relevant, and 5 types are well-marked due to their higher frequency: not wearing respirators when rescuing, talking through respirator in the underground rescue process, not testing underground gas composition dynamically, not carrying a spare respirator, no pro-examination of equipment.
- (5) All results can be used for education.

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REFERENCES

- Donahue, A. K., & Joyce, P. G. (2001). A Framework for Analyzing Emergency Management with an Application to Federal Budgeting. *Public Administration Review*, 61(6), 728-740. doi:10.1111/0033-3352.00143
- Dong, D., & Liu, J. (2006). Status and Development of China Mine Rescue Technology and Equipment. *Safety in Coal Mines*, 10, 62-65. doi:10.3969/j.issn.1003-496X.2006.10.022
- Hoetmer, G. J. (1991). *Emergency Management: Principles and Practice for Local Government*. Washington D. C.: International City Management Association
- Ikeda, Y., Beroggi, G. E. G., & Wallace, W. A. (1998). Supporting Multi-group Emergency Management with Multimedia. *Safety Science*, 30(1-2), 223-234. doi:10.1016/S0925-7535(98)00038-1
- Kong, Q. (2009). Thinking about Coal Mine Rescue Work. *Management & Technology of SME*, 5, 263-264. doi:10.3969/j.issn.1673-1069.2009.13.242
- Li, S. (2007). Discussion about Strengthening the Construction of Mine Rescue Team. *China Coal*, 1, 53-54. doi:10.3969/j.issn.1006-530X.2007.01.020
- Li, X., & Hu, J. (2005). Research and Application of Coal Mine Emergency Rescue Technology. *Coal Engineering*, 4, 62-64. doi:10.3969/j.issn.1671-0959.2005.04.025
- Papamichailh, K. N., & French, S. (2005). Design and Evaluation of an Intelligent Decision Support System for Nuclear Emergencies. *Decision Support Systems*, 41(1), 84-111. doi:10.1016/j.dss.2004.04.014
- Trainor, J. E. (2004). *Searching for a System: Multi-organizational Coordination in the September 11th Trade Center Search and Rescue Response*, master thesis.
- Wang, L., & Ma, S. (2004). Changing Ideas to Improve the Mine Rescue Service. *Safety in Coal Mines*, 9, 48-49. doi:10.3969/j.issn.1003-496X.2004.09.019
- Wybo, J. L., & Kowalski, K. M. (1998). Command Centers and Emergency Management Support. *Safety Science*, (30), 131-138.

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