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The utility of health belief model to explain self-protective behaviour against pneumoconiosis in Chinese underground coal miners: a cross-sectional study

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ABSTRACT

Objectives Coal workers' pneumoconiosis is caused by exposure to respirable coal mine dust. The self-protection of underground coal miners (UCM) plays an irreplaceable role against this threat. The purpose of this study was to evaluate the predictors of self-protective behaviour (SPB) in Chinese UCM based on the health belief model (HBM).

Methods A cross-sectional study was conducted among 341 UCM in January 2016 in Pingdingshan City, Henan Province, People's Republic of China. Data was collected using a self-reported questionnaire, which included questions on sociodemographic characteristics, HBM variables and SPB. An exploratory factor analysis of the principal components with varimax rotation was carried out on the HBM-related items. Pearson's correlation and multiple linear regression analysis were used to assess the relationship between sociodemographic characteristics, HBM variables and SPB.

Results Multiple regression analysis demonstrated the monthly income (B=0.403, p=0.001), the internal cues to action (B=0.380, p<0.001) and external cues to action (B=0.401, p<0.001) as the predictors of UCM's SPB, accounting for 24.8% of total variance (F=34.96, p<0.001), while the cognition variables of HBM were not significantly associated with SPB.

Conclusion The results suggested that both internal and external cues to action were powerful predictors for SPB. These findings highlight that further efforts are required to provide the UCM with periodic health check-up reports and promote the active role of doctors and family members in miners' decision-making to simulate them for better SPB.

Ethics approval All data collection procedures received ethical approval from the Ethics Committee of Xuhui District Centre for Disease Control and Prevention (XHHEC-2016–7).

INTRODUCTION

China is the largest coal producer and consumer country in the world, occupying 46.1% and 50.6% of total production and consumption respectively according to the British Petroleum (BP) Statistical Review of

Strengths and limitations of this study

► The health belief model was applied in this study to explain the Chinese underground coal miners (UCM's) self-protective behaviour (SPB).

► All participants in the present study are from the same coal mine company, which limited the generalisability of the findings to the whole Chinese UCM.

► The smoking history and respiratory symptoms were not investigated in this study. However, the association between smoking and lower levels of attitudes about SPB should not be ignored. Moreover, the respiratory symptoms might be impacted by SPB.

► This study did not investigate the education levels of participants. However, the education levels might also be associated with UCM's SPB, even though the education levels of UCM in China are generally low.

► Underground mining work hours, which was associated with income and dust exposure, need a detailed survey and more attention in future studies.

World Energy 2017.[1] Due to the development of mining technology and the adjustment of energy supply structure, a lot of town/private-owned collieries have been closed or amalgamated, and it is estimated that the number of underground coal miners (UCM) in China decreased to 4.7 million in 2010 to 2014 from 6 million in 2004.[2] The prolonged inhalation of mine dust could contribute to severe lung disease, including coal workers' pneumoconiosis (CWP), which is one of the common occupational diseases in China,[3][4] and severely impacts the health and quality of life of UCM.[5]

According to incomplete statistics, China mainland has reported 770 000 cases of occupational pneumoconiosis up to 2014, and CWP accounted for about 55%. Moreover, the incidence of occupational disease in China nowadays is still comparatively high.[6] In 2016,

31 789 new occupational diseases were reported in China, including 27 992 new cases of occupational pneumoconiosis. Among them, 95.49% of the cases were coal workers' pneumoconiosis and silicosis, which included 16 658 cases and 10 072 cases, respectively.[7] The current situation is far from achieving the target of eliminating pneumoconiosis in 2030 put forward by the WHO and International Labour Organisation.[8]

In China, the survival of patients with pneumoconiosis is not sufficient.[9 10] One survival analysis of CWP patients in a state-owned mine in the east of China from 1963 to 2014 showed that the average survival was 12.1 years after diagnosis of CWP and the average death age was 57.4 years.[11] Another analysis of patients in Changsha from 1956 to 2010 pointed out the life expectancy was 60.12 years.[12] Both results are significantly lower than the 76.1 years of the Chinese average life expectancy reported by the WHO in 2015.[13] The healthcare costs and the lost economical or societal contribution resulting from premature death or disability attributed to the CWP were huge.[14]

To date, there is no published research demonstrating that effective treatment could reverse the process of CWP.[15 16] The most important measure of pneumoconiosis is prevention.[17 18] Ventilation and humidification operations are essential preventive measures to reduce dust density. Exposures to respirable coal mine dust (free Silicon dioxide (SiO_2)<10%) should be limited to 2.5 mg/m^3 as a time-weighted average concentration for up to an 8 hour working day during a 40 hours working week in China.[19] The state administration of work safety of China stipulates that the coal mines should monitor the density of respiratory dust once a month. It also demands that coal mines should organise an occupational health assessment or examination with a subsequent management report for each miner every 2 years.

In addition, personal dust masks also provide significant protection to coal miners.[20] One study in China indicated that the utilisation rate of personal protective equipment was only 72.6%, and only 43% of the respondents reported that they wear the dust mask each time as required.[21] Therefore, improving patients' awareness of preventing CWP and stimulating self-protective behaviour (SPB) is greatly urgent. The coal enterprises are paying more attention to the provision and training of protective equipment to the UCM.[22 23] However, there is still a lack of understanding of UCM's SPB beliefs.

Previous studies showed that some theory-based educational programmes that applied cognitive frameworks could have a positive effect on behavioural adherence.[24 25] The health belief model (HBM) was developed in the 1950s and has been widely drawn on to explain alterations in health-related behaviours.[26] This model is comprised of several components: perceived susceptibility, perceived severity, perceived benefits, perceived barriers and cues to action. Perceived susceptibility describes a person's subjective perception of the risk of developing a health problem. Perceived severity refers to an individual's subjective assessment of the severity of a health problem and its potential consequences. Perceived benefits refer to an individual's perception of the effectiveness of various actions to reduce the threat of diseases. Perceived barriers refer to an individual's perception of the obstacles to behaviour change. Cues to action are internal or external events that determine a person's readiness for action and trigger the decision-making process.[27] Based on the HBM theory, to adopt a preventive action, a person must know the seriousness of health problems, recognise benefits of preventive behaviour, feel lack of serious barriers and perceive the impact from the events, people or things that move them to change their behaviour. HBM has been employed in a variety of public health settings over the years.

In this cross-sectional study, the HBM was utilised as the theoretical framework to design the questionnaire. The purpose of this study was to evaluate the predictors of SPB in Chinese UCM based on HBM. The findings may help the coal mine manager and health professionals to develop feasible interventions to improve adherence to SPB in Chinese UCM.

METHODS

Participants

This cross-sectional study was carried out among male underground coal miners from a state-owned coal mining enterprise in Pingdingshan city, Henan Province, China. Among the company's 4968 employees, 3074 underground coal miners are exposed to the dust, and they are divided into 46 working groups. We randomly selected six working groups with a total of 410 underground coal miners.

In January 2016, the self-reported questionnaires were distributed to 410 underground coal miners in their work fields, 41 refused either because of their work time limitation or poor literacy ability. The response rate was 90.0%. Three hundred sixty-nine questionnaires were collected in the field with full data on measures for 279 questionnaires. There were 62 questionnaires with missing less than four questions and another 28 with more missing, which was determined as incomplete, as which field investigators were not able to check in limited time. Finally , 341 questionnaires were analysed. The valid rate of this survey was 92.4%.

Before filling in the self-reported survey questionnaire, the participants would be informed of the study purpose, data collection methods and how to complete the questionnaire. They also were informed that their participation was completely anonymous and voluntary. Participants were informed about this research and that they have the right to withdraw from the study. Participants who were incapable of completing the questionnaire themselves were assisted by an investigator who read the questions one by one and recorded the answers. After the participants completed the surveys, the field investigators were responsible for checking

the completeness of questionnaires, asking participants to fill the missing information. The research team rechecked questionnaires to decide whether questionnaires were complete before entering data into the database. All investigators in the field are the authors of this paper.

Written informed consent was obtained from each participant.

Instruments

Sociodemographic characteristics

The sociodemographic characteristics included age, gender, marital status, length of employment and monthly income.

HBM variables

In this study, we developed the items that assessed the components of the HBM, and 30 items were combined under five primary constructs: perceived susceptibility (four items), perceived severity (six items), perceived benefits (five items), perceived barriers (four items), cues to action (seven items) and self-protection behaviour (four items).

In order to facilitate respondents' responses to the items, all items were standardised to a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Every subscale's mean was determined by dividing the total points of all the subscale items by the total number of items. Therefore, the mean score of the HBM model variables could range from 1 to 5. The higher score indicates a greater level of belief and self-protective behaviours. Readers can request a questionnaire from the corresponding author.

Statistical analysis

EpiData Entry was used for data entry and documentation. The Statistical Package for the Social Sciences (SPSS V.22.0) was used for data manipulation and analysis. Summary statistics and frequency distributions were used to describe the sociodemographic characteristics of participants. To assess and confirm the underlying factor structure of the pre-designed HBM items, an exploratory factor analysis (EFA) of the principal components with varimax rotation was carried out on the HBM-related items. The following criteria were used in analysing and guiding the obtainment of the results. An eigenvalue >1 was used as a cut-off point to determine the applicability of the pre-designed factors of the HBM. Items with factor loading >0.5 and conceptual relevance were used as criteria for retaining in a factor. Items with loadings >0.4 on two or more factors were excluded. Pearson's correlation and multiple linear regression analysis were used to assess the relationship between sociodemographic characteristics, HBM variables and SPB.

Patient and public involvement

This study has no patient or public involvement.

RESULTS

Sociodemographic characteristics of subjects

The sociodemographic characteristics of participants in the present study are shown in table 1. The 341 participants are all male, with an average age of 38.3 years and an average employment time of 13.2 years. A majority (67.7%) of respondents earned less than 385 pounds per month.

Exploratory factor analysis and descriptive statistics of HBM variables

EFA yielded seven factors with eigenvalues >1 that accounted for 65.9% of total variance. Three items were deleted in light of the criteria mentioned above. The Kaiser-Meyer-Olkin measure (KMO value of 0.81) and Bartlett's test (χ^2=4169, p<0.001) confirmed the adequacy for the EFA. One of the four questions focused on 'perceived susceptibility' was deleted for showing a factor loading >0.4 in another factor ('perceived severity') in the forepart analysis. Two of the seven items about 'cues to action' were cut-off, and the remaining five were divided into two different parts. Combined with the items' connotation, one part was thought to be the cues from self-review and the other from someone's suggestion. Finally, the seven factors were perceived susceptibility, perceived severity, perceived benefits, perceived barriers, internal cues,

Table 1 Sociodemographic characteristics of main study participants (n=341)

Characteristic	Summary statistics
Age (years)	
Mean±SD	38.3±7.9
Range	21 to 55
Length of employment	
Mean±SD	13.2±9.7
Range	1 to 38
Monthly income (£), n (%)	
≤275	53 (15.5)
275 to 330	48 (14.1)
330 to 385	130 (38.1)
>385	96 (28.2)
Missing	14 (4.1)
Marital status, n (%)	
Married	304 (89.1)
Single	23 (6.7)
Others	10 (3.0)
Missing	4 (1.2)
Registered permanent residence, n (%)	
Rural area	126 (37.0)
Urban area	202 (59.2)
Missing	13 (3.8)

Table 2 Factor loading. Reliability coefficient. Mean and SD

Item	Item factor loading	Reliability coefficient(α)	Mean	SD
How agree do you with…[response options ranged from 'strongly disagree'[1] to 'strongly agree'[5]]				
Perceived susceptibility		0.65	9.86	2.61
There is a great possibility that I might suffer from CWP	0.83		3.59	1.13
I am worried about suffering from CWP	0.72		3.67	1.19
I may suffer from CWP next year	0.56		2.60	1.10
Perceived severity		0.89	23.35	5.14
If I suffered from CWP, my life would be greatly affected	0.89		4.04	1.08
If I suffered from CWP, my work would be greatly affected	0.88		4.00	1.09
If I suffered from CWP, my health would be greatly affected	0.85		4.10	1.00
When thinking about CWP, I feel nervous	0.70		3.70	0.99
CWP can't be cured	0.69		3.82	1.12
When thinking about CWP, I will get frightened	0.66		3.69	1.09
Perceived benefits		0.85	21.24	2.77
Wearing a dust mask as required can prevent me from inhaling dust heavily	0.86		4.23	0.70
Wearing a dust mask as required can bring me great benefits	0.85		4.24	0.67
Learning the correct way to wear a dust mask can protect me better	0.82		4.26	0.72
Wearing a dust mask as required can reduce future problems	0.67		4.29	0.71
The quality of dust mask is essential	0.65		4.22	0.69
Perceived barriers		0.78	11.50	3.47
Wearing a dust mask as required makes me feel inconvenient in work	0.81		3.05	1.14
Wearing a dust mask as required makes me feel troublesome	0.79		2.77	1.20
Wearing a dust mask as required makes me feel uncomfortable on the breath	0.78		3.28	1.13
Wearing a dust mask as required could bring ridicules from my workmates	0.66		2.40	1.02
Internal cues		0.68	12.01	1.93
I pay close attention to my body health	0.82		4.17	0.68
I pay close attention to my health examination report	0.72		4.15	0.73
I know my health examination results	0.68		3.70	1.02
External cues		0.79	8.43	1.17
If a doctor advises me to wear a dust mask, I will do it correctly	0.83		4.22	0.61
If family advise me to wear a dust mask, I will do it correctly	0.82		4.21	0.67
Self-protection behaviour		0.75	15.31	2.30
In the past year, I have taken the initiative to look for information about the hazard and protection of dust operations	0.83		3.60	0.87
In the past year, I have received information about the hazard and protection of dust operations	0.79		3.92	0.75
In the past year, I have been wearing dust masks as required	0.66		3.91	0.69
In the past year, I sought medical advice timely when I got sick	0.61		3.88	0.71

CWP, coal workers' pneumoconiosis.

external cues and self-protective behaviour. Factor scores were calculated by summing the subordinate items' scores. The factor loadings based on EFA, Cronbach's alpha, score mean and SD for these scales and items were presented in table 2.

Correlations between sociodemographic characteristics, HBM variables and SPB

The bivariate correlation for the study variables was shown in table 3. It was found that the SPB of UCM only had statistically significant positive correlations with

Table 3 Bivariate correlation of sociodemographic characteristics, HBM variables and SPB

	1	2	3	4	5	6	7	8	9	10
1. Age	1									
2. Length of employment	0.845**	1								
3. Monthly income	−0.254**	−0.307**	1							
4. Perceived susceptibility	−0.055	0.001	−0.100	1						
5. Perceived severity	−0.155**	−0.108*	−0.086	0.497**	1					
6. Perceived benefits	−0.007	0.029	0.042	0.136*	0.331**	1				
7. Perceived barriers	0.034	0.043	−0.092	0.107*	0.072	−0.035	1			
8. Internal cues	0.096	0.079	0.046	−0.074	0.060	0.206**	−0.022	1		
9. External cues	−0.051	−0.020	−0.024	0.074	0.179**	0.281**	−0.093	0.367**	1	
10. Self-protective behaviour	−0.005	0.001	0.190**	−0.036	−0.038	0.166**	−0.081	0.375**	0.325*	1

All P values are two-tailed.
*p<0.05; **p<0.01. HBM, health belief model; SPB, self-protective behaviour.

perceived benefits and cues in all HBM variables. The majority of cognition variables (perceived susceptibility, perceived severity and perceived barriers) had no significant correlations with SPB. In addition, there was a significant positive association between monthly income and SPB, while monthly income was correlated with other sociodemographic characteristics (age and length of employment).

Multiple linear regression analysis accounts for variance of SPB

To explore the predictor variables of SPB, the main independent variables such as age, length of employment, monthly income and all HBM variables entered the regression model analysis. The results of this analysis are shown in table 4. Accordingly, monthly income, internal cues and external cues were significant predictors of SPB in UCM. The overall model significantly explained 24.8% of the variance in SPB (F=34.96, p<0.001).

DISCUSSION

From the perspective of UCM, the present study evaluated predictors of SPB in Chinese UCM based on HBM. The results of multiple linear regression analysis indicated that the level of income, internal and external cues to action were significant predictors to SPB while other cognitive variables in the HBM were not.

Monthly income is significantly associated with SPB. The incomes of UCM in China mainly depend on downhole work hours. The longer downhole work time

Table 4 Multiple linear regression analysis result (n=341)

Variable	B	SE	β	t	p	F	R^2
Constant	6.015	1.600		3.816	0.000	34.96	0.248***
Age	−0.004	0.028	−0.015	−0.162	0.871		
Length of employment	0.007	0.023	0.032	0.330	0.742		
Monthly income	0.403	0.119	0.178	3.397	0.001		
Perceived susceptibility	0.041	0.051	0.047	0.811	0.418		
Perceived severity	−0.053	0.027	−0.119	−1.960	0.051		
Perceived benefits	0.059	0.045	0.071	1.312	0.191		
Perceived barriers	−0.022	0.033	−0.033	−0.662	0.508		
Internal cues	0.380	0.065	0.316	5.805	0.000		
External cues	0.401	0.109	0.205	3.683	0.000		

***P value <0.001.

means a higher risk of CWP in UCM and the need for better SPB. Besides, more disposable personal income also provides support for their health management (eg, better medical experience, additional physical examination).

Cues to action represent internal and external forces that may drive behaviour change and were found to be the key predictors of miner's SPB in our study. Cues to action were divided into two parts based on the EFA and items' connotation. Internal cues represent the individual understanding of physical health status, through the focus on physical examination and the acquisition of results. This kind of understanding may arouse the miner's awareness of the current physical condition and thus take the initiative to implement self-protection. On the other hand, the requirements and reminders from doctors or family members, considered as external cues, also promote workers to protect themselves. As people often comply with doctors' advice, doctors could play critical roles in helping the UCM develop the SPB. Meanwhile, family members of UCM need to understand the occupational hazards of underground coal work and the importance of self-prevention. They are also responsible for reminding UCM to protect their safety and health. Nowadays, the UCM rarely receive regular education about the knowledge of self-protection against the CWP.[28] The external forces should play a more important role in this process. It implies that more efficient use of behavioural cues will help Chinese UCM attach importance to SPB.

The WHO recommends that all workers exposed to coal dust should undergo lifelong health surveillance.[29] Implementing periodic medical examinations and providing timely feedback to UCM could make them aware of their health status and alert them about the potential risk of illness. The chest scanning may allow for CWP detection at an earlier stage and avoid further dust exposure.[3] Although cognitive factors of HBM in this study did not promote better SPB, the education on perceived susceptibility, perceived severity, perceived benefits and perceived barriers for UCM should not be ignored.

This study also contains limitations that should be addressed. First, all participants in this study are from the same coal mine company, which limited the generalisability of the findings to the whole Chinese UCM. Second, this study did not investigate the education levels of participants. However, education levels may also be associated with UCM's SPB, even though the education levels of UCM in China are generally low. Third, this study did not investigate the smoking history of participants. However, the association between smoking and lower levels of attitudes about health-related behaviours should not be ignored.[30] Moreover, the respiratory symptoms might be impacted by SPB. Finally, underground mining work hours, which was associated with income and dust exposure, were neglected in this study and needed precise survey in future studies.

CONCLUSION

This study advances the understanding of Chinese UCM's SPB by using a valid theoretical framework provided by HBM. The results suggested that both internal and external cues to action were powerful predictors for SPB. In order to simulate miners for better SPB, further efforts are needed to provide the UCM with periodic health check-up reports and promote the active role of doctors as well as family members in miners' decision-making.

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