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RESEARCH

Assessing reliability and validity of the Chinese version of Crown–Crisp experience index and its application in coal miners

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Abstract

In China, coal miners are the primary workforce in coal mining, and among all patients with occupational diseases, 90% suffer from pneumoconiosis. Therefore, the psychological problems resulting from the dual pressures of occupational stress and the high risk of occupational diseases among coal miners are significant factors that affect the development of physical and mental health and even production safety. The Crown–Crisp Experience Index (CCEI) is a multidimensional questionnaire that assesses the psychological state of patients. This study aims to test reliability and validity of Chinese version of the CCEI questionnaire using factor analysis, and apply it to coal miners. We recruited a total of 900 participants from different occupational stages in coal mining, including active miners, Coal Workers' Pneumoconiosis (CWP) patients, and retired miners, to evaluate the reliability and validity of the Chinese version of the CCEI questionnaire. A questionnaire survey was conducted on three groups of 1000 individuals each, including active coal miners, retired coal miners, and pneumoconiosis patients, to determine the detection rate of psychological problems in each group. An analysis was performed for each group to explore the primary factors influencing anxiety. The exploratory factor analysis yielded six principal components that accounted for a total of 79.389% of variances. The confirmatory factor analysis showed that the Chi-square freedom ratio (χ^2/df) was 1.843, the root mean square error approximation was less than 0.044, and the comparative fit index was 0.938 and Tucker–Lewis index (TLI) was 0.934. The Cronbach's alpha coefficient was 0.948, and the scale-level content validity index (S-CVI) was 0.88. Effective questionnaires were obtained from 98.5%, 96.9%, to 91.0% of pneumoconiosis patients, active miners, and retired miners, respectively, with the incidence rates of psychological problems being 21%, 35.8%, and 13.6%, respectively. Compared with retired miners, active miners showed higher levels of psychological problems in the dimensions of depressive symptoms, free-floating anxiety and somatic symptoms, whereas pneumoconiosis patients had higher levels of psychological problems in the dimensions of phobic anxiety and somatic symptoms. This study demonstrates that the Chinese version of the CCEI is highly reliable and valid and can be used as a screening tool to measure patients' anxiety and fear levels in coal minders. Miners face distinct psychological challenges at different stages and require targeted screening and interventions.

Keywords Pneumoconiosis · Miner · Mental disorder · Factor analysis

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1 Introduction

Coal Workers' Pneumoconiosis (CWP) is a systemic disease characterized by the diffuse fibrosis of lung tissues, which is mainly caused by the long-term inhalation of mineral dust during occupational activities like coal mining (Qi et al. 2021). To reduce the occurrence of pneumoconiosis, strict exposure limits have been set, and personal protective equipment such as masks, goggles, and protective clothing have been implemented. Currently, the allowable exposure limit for respirable coal mine dust (RCMD) in China is 2.5 mg/m^3, and with the upgrading of occupational protection measures, such as the use of masks, the incidence of pneumoconiosis in China has decreased in recent years (Decision of the ministry of emergency management on amending the coal mine safety regulations 2022). Despite a more than 50% reduction in the incidence rate of pneumoconiosis compared to 2012, there were still 11,809 new cases of occupational pneumoconiosis in China in 2021 (The National Health Commission released the 2021 2022). Pneumoconiosis is a chronic disease that can only be 100% cured through lung transplantation (Hall et al. 2019). Patients with pneumoconiosis may experience weakened lung function, decreased immunity, and are susceptible to respiratory infections (Bell and Mazurek 2020). Due to the prolonged and debilitating nature of the disease, patients are prone to negative emotions such as anxiety, fear, pessimism, and depression (Morrison et al. 2017). Miners are a high-risk group for pneumoconiosis, facing various work-related pressures and the risk of occupational disease. The resulting psychological problems not only affect the individual's quality of life but also pose a hidden danger to workplace safety. Therefore, timely identification of the psychological status of miners at different stages of their career and corresponding interventions can prevent adverse events, improve their quality of life, and enhance their well-being.

To assess the psychological state of patients, commonly used tools in China include the Self-rating Anxiety Scale (SAS) (Cheng et al. 2017), Self-rating Depression Scale (SDS) (Smith et al. 2018), and Depression Anxiety Stress Scale-21 (DASS-21) (Jiang et al. 2020), which are widely recognized internationally. However, these tools tend to focus on specific aspects of psychological problems. In contrast, the Somatic Symptom Scale SCL-90 provides a more comprehensive evaluation (Dang et al. 2021), but its extensive item list and lengthy survey process may lead to impatience among respondents, especially in China where outpatient services are heavily burdened due to limited medical resources (Li et al. 2020). Consequently, there is an urgent need to develop a measurement tool that can assess multiple aspects of psychology within a short timeframe, enabling medical professionals to quickly screen for issues in one or more domains.

The Crown–Crisp Experience Index (CCEI) is a quantitative assessment tool that measures patients' phobia levels using a questionnaire (Crown and Crisp 1966). This questionnaire has been widely employed in clinical studies on various conditions such as heart disease (Haines et al. 1987), tinnitus (Stephens and Hallam 1985), anorexia nervosa (Hsu and Crisp 1980), ovarian cancer (Poole et al. 2016), and even attention deficit hyperactivity disorder (ADHD) in children (Bolea-Alamañac et al. 2019). Therefore, in order to assess the psychological status of the miner population, the present study aims to localize and revise the CCEI questionnaire in Chinese and employ factor analysis to test its reliability and validity. The study further aims to investigate and compare anxiety and fear indices among active miners, CWP patients, and retired miners at different career stages, with the objective of laying a foundation for early identification of negative psychological states.

2 Materials and methods

2.1 The CCEI questionnaire

The Crown–Crisp Experience Index is a self-rating scale that was developed in 1966 by Crown and Crisp, psychiatry professors at Middlesex Hospital in London, UK (Crown and Crisp 1966). The questionnaire comprises six dimensions, each with eight items. The six dimensions assessed by the questionnaire are free-floating anxiety (FFA items 1, 7, 13, 19, 25, 31, 37, 43), phobic anxiety (PHO items 2, 8, 14, 20, 26, 32, 38, 44), obsessive–compulsive traits and symptoms (OBS items 3, 9, 15, 21, 27, 33, 39, 45), somatic symptoms (SOM items 4, 10, 16, 22, 28, 34, 40, 46), depressive symptoms (DEP items 5, 11, 17, 23, 29, 35, 41, 47), and hysterical traits and symptoms (HYS items 6, 12, 18, 24, 30, 36, 42, 48). The questionnaire is a concise tool for evaluating common phobias and anxiety disorders, such as claustrophobia, pathophobia, acrophobia, and demophobia levels. Each item has a score range of 0–2 points, and each dimension ranges from 0 to 16 points, with a total score of 0 to 96. The survey also includes "reversed items," where a higher score indicates a greater degree of anxiety and phobia.

2.2 The CCEI questionnaire translation and cross-cultural adaptation

In accordance with the principles of cross-cultural adaptation (Guillemin et al. 1993), the localization process of the Chinese version of CCEI is depicted in Fig. 1. A total of 15 experts, as shown in supplementary Table 1 in medical-related fields were invited to evaluate the expression and

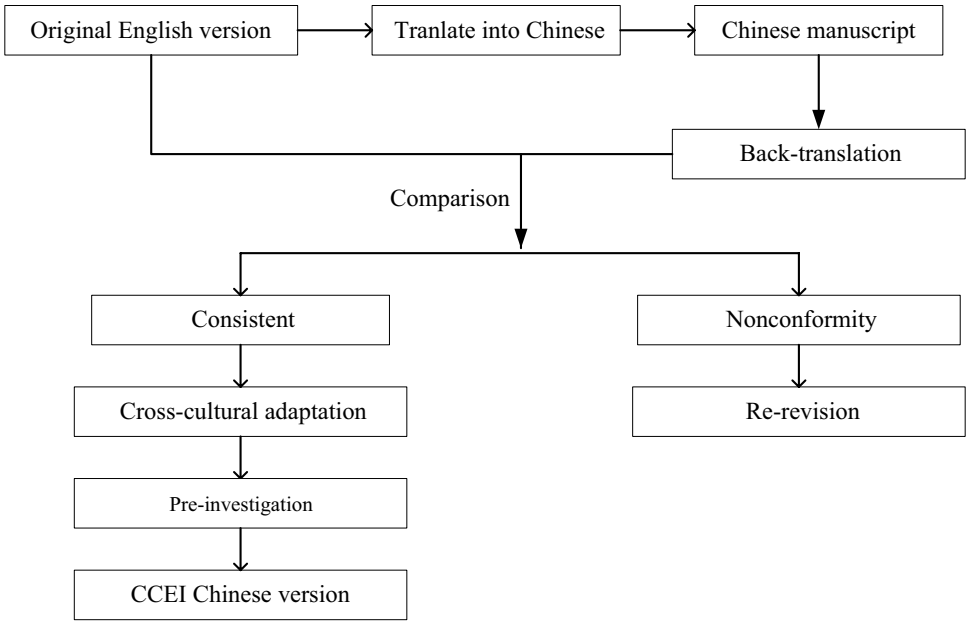

Fig. 1 The localization process of the Chinese CCEI

make it more idiomatic. The invitees completed relevant forms, and the first round of expert consultation was conducted. Controversial items underwent a second round of expert consultation. After two rounds, the expert judgment coefficient (Ca) was 0.93 and the familiarity degree coefficient (Cs) was 0.89, according to the formula authority coefficient (Cr) = (Ca + Cs)/2 (Li et al. 2021), resulting in an expert authority coefficient (Cr) of 0.91. This score is greater than 0.9 and indicates that the experts unanimously suggested deleting item 9, i.e. *Do you think that "cleanliness is next to godliness?*. Consequently, the questionnaire was reduced to 47 items across six dimensions. It is worth noting that cultural differences were taken into account throughout the localization process.

2.3 Pre-investigation

In this study, we adopted convenience sampling to distribute a total of 30 questionnaires for pilot study, with 10 questionnaires each given to active miners, CWP patients, and retired miners, respectively. A 3-point scoring method was adopted; that is, answering "yes" tallies 2 points, "sometimes" 1 point, and "no" 0. For reverse items, the scoring is exactly the opposite. Given the low literacy levels and advanced age of the study subjects, the current investigation employed one-to-one surveys conducted by six trained research members, who carefully gathered and incorporated the subjects' opinions and suggestions regarding each questionnaire item. The questionnaire's format, content, item options, and completion time were reported to be reasonable. The questionnaire was found to take approximately 12–15 min to complete.

2.4 Participants

To ensure the reliability and validity of the questionnaire, the study followed the principle that the number of participants should be 5–10 times greater than the number of questionnaire items (Myers et al. 2011). We recruited a total of 900 coal mines from different occupational stages, including 300 active miners, 300 CWP patients, and 300 retired miners, to assess the reliability and validity of the Chinese version of the CCEI questionnaire. A questionnaire survey and subgroup analysis were conducted on three groups of 1000 individuals each, including active miners, CWP patients, and retired miners to explore the primary factors influencing anxiety.

2.5 Data collection

A total of 900 questionnaires were distributed and collected from different occupational stages. Of these, 31 were incomplete and therefore excluded from analysis, leaving a total of 869 valid questionnaires. The survey's effective response rate was 96.6%, meeting the standard criteria for surveys. Additionally, 1000 individuals from each of the active miner, CWP patient, and retired miner groups were recruited, with valid responses obtained from

969, 985, to 910 individuals, respectively. The effective rates of the survey were 96.9%, 98.5%, and 91.0% for the coal miner, CWP patient, and retired miner groups, respectively.

2.6 Statistical analysis methods

The data input was performed by using Epidata 3.1 software, and subsequently, the data were randomly assigned into two groups. One group was used for exploratory factor analysis (EFA) through SPSS 22.0 ($n = 435$), while the other was used for confirmatory factor analysis (CFA) using AMOS 25.0 ($n = 434$). The reliability and validity of the study were evaluated using several statistical methods including Cronbach's alpha, composite reliability, and goodness of fit indices (McDonald and Ho 2002). In addition, the content validity index (CVI) and correlation coefficient were used to assess the reliability and validity of the Chinese version of the CCEI. The quantitative aspects of the study were described by the composition ratio, mean, standard deviation, and M (SD).

3 Results

The 869 samples used to test the reliability and validity of the questionnaire were drawn from three groups: 292 active miners, 290 CWP patients, and 287 retired miners. The nature of the work under investigation is specific to certain settings, thus the survey participants were restricted to males aged 25–94, with a mean (SD) age of 55.35 (15.74) years. The majority of miners are exhibit low levels of education, as shown in supplementary Table 2).

3.1 Exploratory factor analysis of CCEI Chinese version

The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity for the Coal Workers' Pneumoconiosis Cognitive Emotion Inventory (CCEI) questionnaire yielded a value of 0.904, exceeding the threshold of 0.9, indicating suitability for factor analysis. Varimax with Kaiser normalization is then applied to extract 6 factors from 47 items (Fig. 2). The six factors are: DEP (items 5, 11, 17, 23, 29, 35, 41, 47), FFA (items 1, 7, 13, 20, 25, 31, 37, 43), PHO (items 2, 8, 14, 19, 26, 32, 38, 44), SOM (items 4, 10, 16, 22, 28, 34, 40, 46), HYS (items 6, 12, 18, 24, 30, 36, 42, 48), and OBS (items 3, 15, 21, 27, 33, 39, 45). According to the study, a total of 79.389% variance is explained. We have recoded the items in the questionnaire. The detailed information of six factors is shown in Table 1, including FFA (items from FFA1 to FFA8), PHO ((items from PHO1 to PHO8), OBS (items from OBS1 to OBS7), SOM (items from SOM1 to SOM8), DEP (items from DEP1 to DEP8), HYS (items from HYS1 to HYS8).

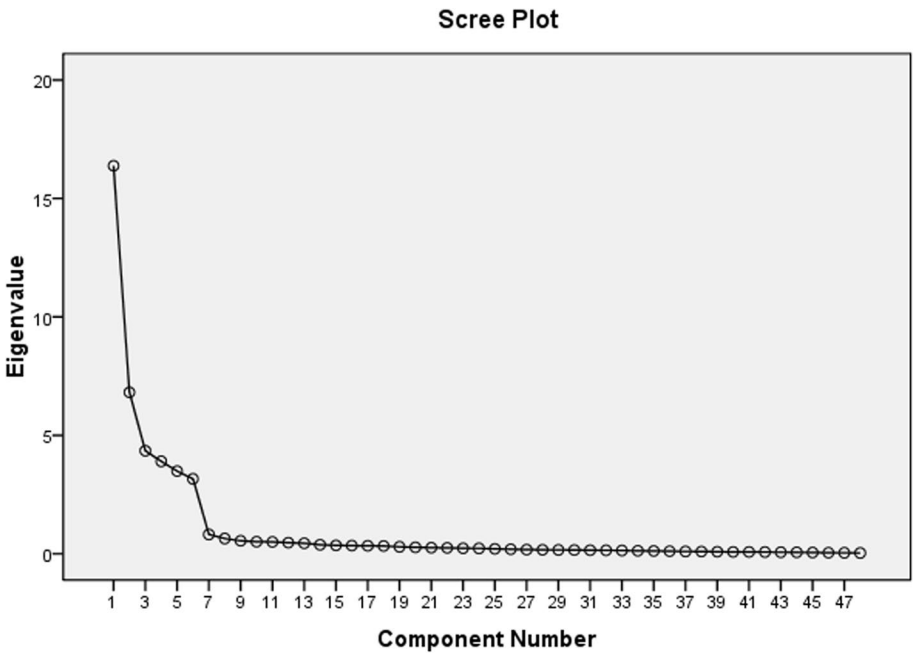

Fig. 2 Scree plot of CCEI

Table 1 Component matrix of each dimension of the CCEI ($n=435$)

Item		Component					
		1	2	3	4	5	6
1→FFA1	Do you often feel upset for no obvious reason ?	0.216	0.259	0.222	**0.821**	0.008	0.146
7→FFA2	Have you felt as though you might faint ?	0.138	0.112	0.112	**0.857**	−0.034	0.074
13→FFA3	Do you feel uneasy and restless?	0.012	0.044	0.127	**0.831**	−0.085	0.056
20→FFA4	Do you feel uneasy travelling on buses or the Underground even if they are not crowded?	0.181	0.146	0.134	**0.868**	−0.028	0.111
25→FFA5	Would you say you were a worrying person?	0.180	0.089	0.127	**0.869**	−0.056	0.128
31→FFA6	Do you often feel "strung − up" inside?	0.260	0.127	0.104	**0.775**	0.000	0.148
37→FFA7	Have you ever had the feeling you are "going to pieces"?	0.223	0.123	0.134	**0.825**	0.015	0.146
43→FFA8	Do you have bad dreams which upset you when you wake up?	0.138	0.046	0.086	**0.851**	−0.038	0.106
2→PHO1	Do you have an unreasonable fear of being in enclosed spaces such as shops, lifts, etc0.?	−0.170	−0.173	0.064	−0.114	**0.795**	0.024
8→PHO2	Do you find yourself worrying about getting some incurable illness?	−0.004	−0.070	0.080	−0.062	**0.852**	−0.107
14→PHO3	Do you feel more relaxed indoors?	0.036	−0.024	0.029	−0.055	**0.875**	0.050
19→PHO4	Do you sometimes feel really panicky?	0.009	−0.035	0.100	−0.054	**0.880**	0.021
26→PHO5	Do you dislike going out alone?	0.060	−0.001	0.150	−0.005	**0.875**	0.008
32→PHO6	Do you worry unduly when relatives are late cominghome?	0.033	−0.027	0.121	−0.008	**0.883**	0.006
38→PHO7	Are you scared of heights?	0.074	0.012	0.136	0.052	**0.851**	0.051
44→PHO8	Do you feel panicky in crowds?	0.036	−0.008	0.057	0.030	**0.894**	0.006
3→OBS1	Do people ever say you are too conscientious ?	**0.847**	0.154	0.177	0.203	0.007	0.230
15→OBS2	Do you find that silly or unreasonable thoughts keep recurring in your mind?	**0.855**	0.185	0.161	0.186	0.013	0.173
21→OBS3	Are you happiest when you are working?	**0.798**	0.199	0.180	0.214	0.043	0.169
27→OBS4	Are you a perfectionist?	**0.822**	0.189	0.214	0.215	0.022	0.215
33→OBS5	Do you have to check things you do to an unnecessary extent?	**0.821**	0.157	0.168	0.152	0.018	0.210
39→OBS6	Does it irritate you if your normal routine is disturbed?	**0.833**	0.166	0.123	0.168	−0.004	0.158
45→OBS7	Do you find yourself worrying unreasonably about things that do not really matter?	**0.859**	0.198	0.199	0.174	0.031	0.168
4→SOM1	Are you troubled by dizziness or shortness of breath ?	0.184	**0.826**	0.069	0.102	−0.085	0.183
10→SOM2	Do you often feel sick or have indigestion?	0.192	**0.815**	0.084	0.138	−0.008	0.090
16→SOM3	Do you sometimes feel tingling or pricking sensations in your body, arms or legs?	0.091	**0.854**	0.085	0.075	−0.057	0.127
22→SOM4	Has your appetite got less recently?	0.142	**0.889**	0.133	0.124	−0.047	0.131
28→SOM5	Do you feel unduly tired and exhausted?	0.103	**0.813**	0.161	0.083	−0.045	0.105
34→SOM6	Can you get off to sleep alright at the moment?	0.175	**0.882**	0.131	0.104	−0.031	0.131
40→SOM7	Do you often suffer from excessive sweating or fluttering of the heart?	0.148	**0.872**	0.116	0.114	−0.051	0.120
46→SOM8	Has your sexual interest altered?	0.195	**0.845**	0.141	0.137	−0.026	0.141
5→DEP1	Can you think as quickly as you used to ?	0.149	0.147	0.058	0.111	−0.010	**0.862**
11→DEP2	Do you feel that life is too much effort?	0.216	0.189	0.196	0.137	0.049	**0.820**
17→DEP3	Do you regret much of your past behaviour?	0.172	0.165	0.097	0.110	−0.002	**0.849**
23→DEP4	Do you wake unusually early in the morning?	0.242	0.166	0.123	0.185	0.029	**0.819**
29→DEP5	Do you experience long periods of sadness?	0.239	0.151	0.099	0.133	0.015	**0.863**
35→DEP6	Do you have to make a special effort to face up to a crisis or difficulty?	0.233	0.234	0.219	0.159	0.056	**0.849**
41→DEP7	Do you find yourself needing to cry?	0.257	0.241	0.188	0.173	0.031	**0.798**
47→DEP8	Have you lost your ability to feel sympathy for other people?	−0.001	−0.066	0.065	−0.005	−0.050	**0.694**
6→HYS1	Are your opinions easily influenced ?	0.194	0.147	**0.820**	0.168	0.102	0.127
12→HYS2	Have you, at any time in your life, enjoyed acting?	0.168	0.143	**0.853**	0.111	0.150	0.164
18→HYS3	Are you normally an excessively emotional person?	0.199	0.106	**0.847**	0.130	0.124	0.125
24→HYS4	Do you enjoy being the centre of attention?	0.114	0.125	**0.862**	0.087	0.104	0.111
30→HYS5	Do you find that you take advantage of circumstances for your own ends?	0.177	0.113	**0.812**	0.126	0.112	0.129
36→HYS6	Do you often spend a lot of money on clothes?	0.170	0.159	**0.859**	0.130	0.106	0.161
42→HYS7	Do you enjoy dramatic situations?	0.192	0.123	**0.826**	0.125	0.071	0.077
48→HYS8	Do you sometimes find yourself posing or pretending?	0.072	0.043	**0.856**	0.158	0.086	0.077
Eigenvalue		6.629	6.580	6.427	6.295	6.109	6.067
Total variance explained (%)		13.810	13.708	13.390	13.114	12.727	12.640

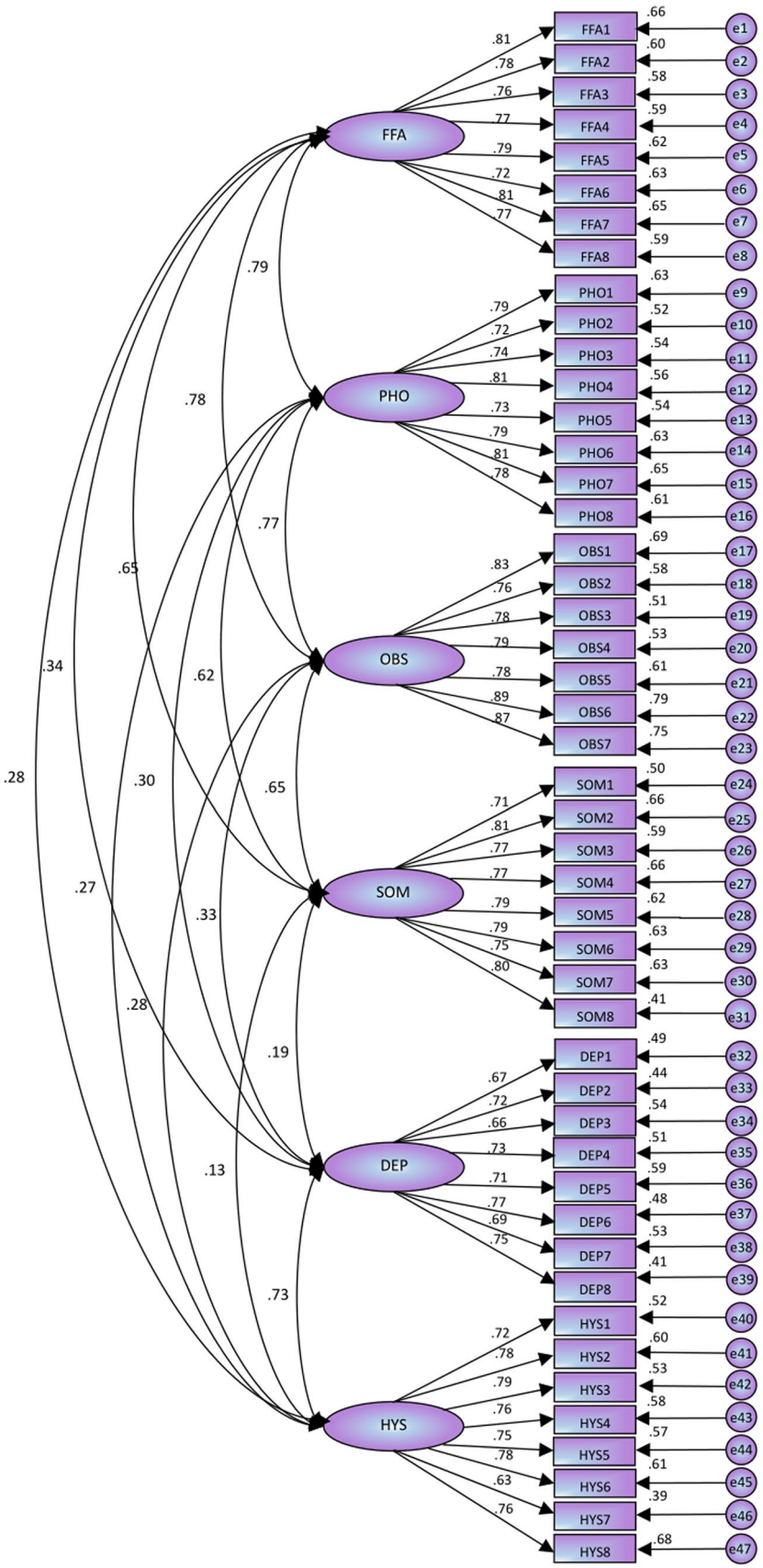

Fig. 3 Path diagram of each dimension

Table 2 Fit indexes of Chinese CCEI ($n=434$)

Index	χ^2	d*f*	*P*	χ^2/d*f*	CFI	TLI	RMSEA(90%CI)
CFA	1878.471	1019	0.00	1.843	0.938	0.934	0.038(0.041–0.047)
Criterion	–	–	< 0.05	< 3	> 0.9	> 0.9	< 0.1–

df, degree of freedom; CFI, Comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; 90% CI, 90% confidence interval for RMSEA

Table 3 Parameters estimation result ($n=434$)

Path diagram			Unstd	S.E	t-value	STD	CR	AVE
FFA1	←	FFA	1.000			0.813	0.928	0.617
FFA2	←	FFA	0.862	0.067	12.921	0.775		
FFA3	←	FFA	0.947	0.070	13.581	0.764		
FFA4	←	FFA	0.952	0.070	13.686	0.769		
FFA5	←	FFA	1.007	0.071	14.235	0.786		
FFA6	←	FFA	1.053	0.071	14.934	0.795		
FFA7	←	FFA	1.012	0.068	14.915	0.807		
FFA8	←	FFA	0.921	0.069	13.395	0.770		
PHO1	←	PHO	1.000			0.790	0.922	0.596
PHO2	←	PHO	0.883	0.067	13.101	0.721		
PHO3	←	PHO	0.880	0.067	13.084	0.736		
PHO4	←	PHO	0.934	0.067	13.948	0.810		
PHO5	←	PHO	0.763	0.066	11.622	0.731		
PHO6	←	PHO	0.966	0.068	14.303	0.794		
PHO7	←	PHO	0.958	0.067	14.367	0.806		
PHO8	←	PHO	1.012	0.069	14.703	0.782		
OBS1	←	OBS	1.000			0.831		
OBS2	←	OBS	0.849	0.062	13.798	0.764		
OBS3	←	OBS	0.920	0.062	14.786	0.78		
OBS4	←	OBS	0.967	0.060	16.030	0.793		
OBS5	←	OBS	0.942	0.061	15.538	0.779		
OBS6	←	OBS	1.017	0.061	16.735	0.889		
OBS7	←	OBS	1.125	0.066	16.462	0.865	0.933	0.665
SOM1	←	SOM	1.000			0.708		
SOM2	←	SOM	0.985	0.070	13.992	0.813		
SOM3	←	SOM	0.822	0.070	11.741	0.769		
SOM4	←	SOM	0.989	0.070	14.088	0.767		
SOM5	←	SOM	1.019	0.071	14.263	0.79		
SOM6	←	SOM	1.050	0.072	14.568	0.792		
SOM7	←	SOM	1.074	0.072	14.923	0.795		
SOM8	←	SOM	0.554	0.069	8.003	0.639	0.916	0.579
DEP1	←	DEP	1.000			0.673		
DEP2	←	DEP	1.229	0.139	8.823	0.702		
DEP3	←	DEP	0.898	0.121	7.432	0.660		
DEP4	←	DEP	1.324	0.145	9.156	0.732		
DEP5	←	DEP	1.289	0.142	9.071	0.716		
DEP6	←	DEP	1.421	0.150	9.501	0.766		
DEP7	←	DEP	1.184	0.137	8.672	0.694		
DEP8	←	DEP	1.421	0.150	9.451	0.748	0.891	0.507
HYS1	←	HYS	1.000			0.720		
HYS2	←	HYS	0.999	0.079	12.585	0.776		
HYS3	←	HYS	1.093	0.078	14.023	0.793		
HYS4	←	HYS	1.014	0.078	13.069	0.760		
HYS5	←	HYS	0.912	0.076	12.038	0.752		
HYS6	←	HYS	1.038	0.077	13.549	0.783		
HYS7	←	HYS	1.018	0.106	10.525	0.628		
HYS8	←	HYS	0.840	0.074	11.325	0.762	0.910	0.560

3.2 Confirmatory factor analysis of CCEI Chinese version

Structural Equation Modeling (SEM) is a statistical modeling approach that involves the analysis of the relationships between latent variables and observed variables, which are measured by multiple indicators (Alavi et al. 2020). In this study, a total of 47 observed variables were used, with FFA, PHO, OBS, SOM, DEP, and HYS serving as latent variables. AMOS 25.0 was utilized to construct a path diagram to confirm the theoretical structure of exploratory factor analysis (Fig. 3). Confirmatory factor analysis fit indices presented in Table 2. The estimation results of the parameters indicate that the six dimensions of the CCEI scale exhibit CR value exceeding 0.6 and AVE value exceeding 0.5, and the correlation coefficients among the factors are lower than the AVE value, as shown in Table 3.

3.3 Internal consistency coefficient of CCEI Chinese version

The internal consistency of the questionnaire and each dimension was evaluated using Cronbach's α coefficient, as shown in Table 4, with values ranging from 0.899 to 0.936, exceeding the threshold of 0.90. Split-half reliability was also assessed and found to be greater than 0.8, indicating excellent internal consistency of the questionnaire (Terwee et al. 2007).

3.4 Content validity index of CCEI Chinese version

Content validity index (CVI) is sub-divided into item-level CVI (I-CVI) and scale-level CVI (S-CVI). Typically, the validity is based on expert comment. I-CVI equals to the number of the experts scoring 4 or 5 for the importance of the research/total number of the experts. S-CVI equals to the number of items with a 4 or 5 scores/total number of items. In this research, the results show that I-CVI is 0.73–1.00, S-CVI is 0.88, all greater than 0.7, indicating good content validity (Zhong et al. 2020).

Table 4 Reliability result of the CCEI ($n = 435$)

Item	Item number	Cronbach's Alpha	Split-half reliability
Chinese CCEI	47	0.948	0.952
FFA	8	0.958	0.919
PHO	8	0.954	0.899
OBS	7	0.967	0.942
SOM	8	0.962	0.917
DEP	8	0.957	0.938
HYS	8	0.962	0.929

3.5 Mental disorder between miner workers and CWP patients and retired miners

In order to further clarify the actual application of the scale, we compared the detection rates of psychological disorders among miners, pneumoconiosis patients, and retired miners (supplementary Table 3). The detection rates of psychological disorders in active miners, pneumoconiosis patients and retired miners were 35.8%, 21.0%, and 13.6%, respectively. In addition, in order to further understand the proportion of factors affecting psychological problems in different populations, we conducted a subgroup analysis for each group. Taking 20% as the cut-off value, it shows that the psychological barriers among miners mainly focus on DEP, FFA and SOM dimensions, and the positive rates are 35.1%, 36.4% and 33.2%, respectively. The pneumoconiosis population mainly focused on PHO and SOM, and the positive detection rates were 39.5% and 29.2%, respectively. The detection rate of retired miners is below 20% in all dimensions, as shown in Fig. 4.

4 Discussions

4.1 Reliability and validity of Chinese CCEI

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) are widely recognized as reliable methods for evaluating the stability and structural validity of questionnaires. EFA assesses the relationship between observed and latent variables through factor loading (DeVon et al. 2007), and the sampling adequacy is first determined using Kaiser–Meyer–Olkin before data analysis. A result greater than 0.90 indicates that the sample is suitable for factor analysis. In conducting EFA, the cumulative variance contribution rate of the common factors must exceed 60%, and the factor load of each item on its common factor must be greater than 0.4, indicating that each item reflects the information of a particular dimension. In this study, the factor load of each item and its dimensions exceeded 0.5, except for item 19, which was transferred from FFA to PHO, and item 20, which was transferred from PHO to FFA, based on content relevance. The communalities of each dimension and the CCEI were all greater than 0.5, indicating that the components were adequately explained.

Confirmatory Factor Analysis (CFA) is a reliable method for testing the structural assumptions of an established model by evaluating goodness of fit (Bagozzi et al. 1981). For ease of identification, the serial numbers of each item were recoded. The results of the CFA indicate that the fit indices in Table 2 are consistent with the reference values. In conjunction with the results in Table 3, each item has a loading above 0.6 under its respective factor, with CR values

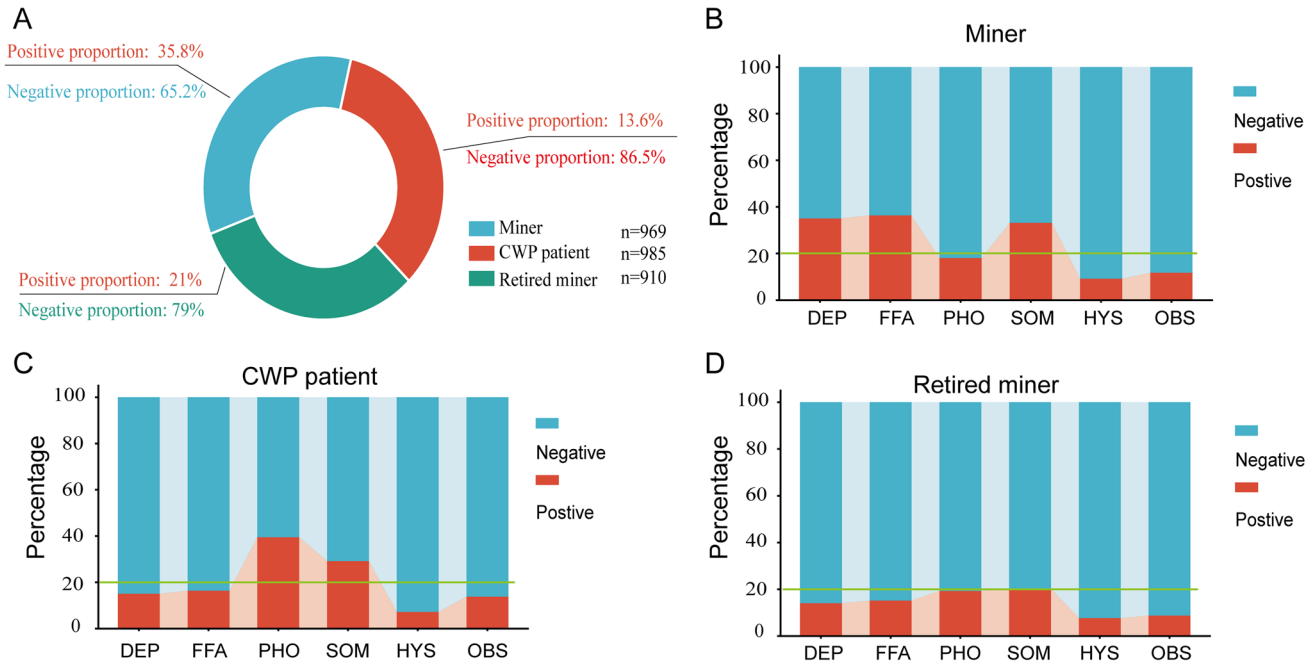

Fig. 4 The detection rate of mental disorders **a** The detection of the total score of the three groups of mental disorders; **b** The detection of psychological disorders in each dimension of the active miners; **c** The detection of psychological disorders in each dimension of CWP: **d** The detection of each dimension of retired miner detection of mental disorders

greater than 0.8 and AVE greater than 0.5. This indicates that the items in the CCEI scale have a certain degree of discrimination, and the model has an ideal structure capable of identifying the degree of response of different investigators.

Table 4 shows that the reliability indicators of the Chinese version of the CCEI are higher compared to the original study conducted by Crown and Crisp in 1966, which may be attributed to the significant increase in sample size in this study. The Cronbach's α coefficients of the total questionnaire and each dimension were all greater than 0.9, and the split-half reliability coefficients obtained by grouping odd and even numbered items were all greater than 0.8, indicating good internal consistency of the questionnaire (Boparai et al. 2018).

Content validity is typically assessed through expert reviews, which serve as an indication of the accuracy of the measured content or topic (Hayes and Preacher 2010). In general, content validity is established based on experts' comments, with I-CVI representing the number of experts who score 4 or 5 for the importance of the research divided by the total number of experts, and S-CVI representing the number of items with a score of 4 or 5 divided by the total number of items (Egger-Rainer 2018). In this study, both I-CVI and S-CVI exceeded 0.7, indicating that the Chinese CCEI has strong content validity.

4.2 Coal miners mental disorder

Miners working underground are all male. The results of the comparison among active miners, CWP patients, and retired miners show that the highest detection rate of psychological problems in active miners is 35.8%, mainly focusing on the dimensions of DEP, FFA, and SOM. The main reasons for the high prevalence of psychological issues in active miners are likely due to the harsh operating environment underground and the pressure from work management. These findings are consistent with the research reported by Ailing Fu et al. (2022). The second is the detection rate of psychological disorders in CWP patients, which is 21%, mainly focusing on the dimensions of PHO and SOM. According to the national policy (Shi et al. 2020), once pneumoconiosis is diagnosed, patients can enjoy free medical treatment, which largely eliminates patients' concerns. But pneumoconiosis will have the symptoms of respiratory disorder and hypoxia. For those suffering from pneumoconiosis, they are worried that they will not get timely help, especially when they live alone, which will cause fear to patients. It is worth noting that the detection rate of psychological problems in retired miners without pneumoconiosis is only 13.6%, which is lower than the incidence of psychological problems in the

general elderly. It shows that the quality of life of retired miners is quite satisfactory after retiring from their posts. On the one hand, they are out of the high-risk occupational environment, and can freely spend their time while receiving monthly pensions. Compared with the stress during work, it is a state from bitter to sweet. This study suggests that miners have different psychological problems at different career stages. Coal operators should pay attention to the psychological problems of miners and formulate targeted psychological intervention measures to improve the mental health and quality of life of miners.

5 Conclusions

The dimensions as well as the questionnaire in this study enjoy sound internal consistency and good structural validity and reliability. It thus can be used as one of the measurement tools to assess the phobia indexes of coal miners at different periods of their working and retirement life. Though this study is based on coal miners, it is expected the Chinese CCEI can be applied to other types of patients in the future, for whom it is critical to assess psychological problems in a short period of time.

It should be noted that this study has some limitations. The limitations may include: (1) Although the sample size is relatively considerable, the study focuses on the population of only one city, which may have potential environmental impacts. (2) The questionnaires involved in this study are all men, and whether it can be applied to the female population still needs to be further explored.

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Declarations

Conflict of interest All authors declared that they have no conflict of interest.

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