INFLUENCING FACTORS OF COVID-19 ON OCCUPATIONAL HEALTH AND SAFETY IN CONSTRUCTION ENTERPRISES

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Abstract. To explore the influence factors and degree of the outbreak of COVID-19 on Occupational Health and Safety (OHS) of construction enterprises, this study first uses Structural Equation Model (SEM) to construct and verify the Human factors influenced model through empirical investigation and then uses the Chi-squared Automatic Interaction Detection (CHAID) decision tree, Ishikawa analysis to conduct in-depth analysis on the influence of human factors. The results show that the human factors model constructed in this study is reliable, and human factors are directly and positively affected by method factors and management factors, while management factors are directly and positively affected by material factors, and method factors are directly and positively affected by environmental factors. The results also show that the two sub-factors of human factors, Q7 (self-confidence), and Q8 (psychological counseling), also have a multi-level decision-making relationship with other factors. The key sub-factors of other factors are Q24 (differential prevention and control) and Q25 (health building); Q11 (epidemic prevention materials), Q12 (fire fighting facilities), Q20 (remote sharing); Q15 (the legal system), Q16 (safety management). This research model and decision-making method can find out the deep-seated influencing factors on human factors, to strengthen factor control and reduce the adverse impact of COVID-19 on OHS management of construction enterprises.
Keywords: *EHS, SEM, CHAID decision tree, human causal hypothesis*

Introduction

The current global epidemic of COVID-19 has had a huge impact on all walks of life (Wu et al., 2021). As construction enterprises are one of the high-risk industries (Chen and Cao, 2021; Jiang et al., 2020; Yao et al., 2021), the impact of the superposition of COVID-19 has brought more risk factors to the Occupational Health and Safety (OHS) of construction enterprises (Dennysmith et al., 2021; Kaklauskas et al., 2021). The OHS management system is an integral part of the EHS management system, which integrates the Environmental Management System (EMS) and the Occupational Health and Safety Management System (OHSMS). OHS management of construction enterprises is one of the core issues concerned by all countries. There are many types of influencing factors that constitute OHS management. Some scholars believe that OHS of construction enterprises needs effective hierarchical factor management and put forward the "five-factor method" (main factors, secondary factors, weak factors, unrelated factors, and expected factors) (Cao et al., 2021a), More scholars put forward the "five-factor model" (human factor, material factor, method factor, management factor, and environmental factor) (Cao et al., 2021b; McDonald et al., 2018). Due to the special environment of

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COVID-19, the relationship between the above-mentioned constituent factors and the composition of sub-factors of each factor is bound to be inconsistent with the traditional influencing factors. Therefore, the main purpose of this study is to explore the hypothetical relationship between the factors in the "five-factor model" and to deeply analyze the influence relationship of each sub-factor on the five factors.

The five factors to be studied in this paper are human factors, material factors, method factors, management factors, and environmental factors. Human factors are mainly divided into man-unsafe behavior and material unsafe state (Jiang et al., 2020). Workers working in specific environments and activities have an increased risk of certain infectious diseases (Li and Wang, 2021; Lin et al., 2021). Considering occupational risk factors and controlling occupational exposure can help prevent the spread of diseases in the workplace and protect the health of workers (Su et al., 2019). Physical factors usually refer to the influence of equipment and materials used on the construction site (Eyles et al., 2019). At the same time, economic input of equipment and materials and construction cost saving are also the main factors influencing the improvement of the management level (Kang and Wu, 2020; Luo et al., 2022). Among the management factors, efforts to carry out education, publicity, and training, and combine the rights of safety and protection with legislation will help to reduce the occurrence of occupational injuries (Kiconco et al., 2019). The study on the limiting factors of implementing safety measures in contractors found that the factors affecting safety practice are: poor management of occupational safety and health; Lack of training and knowledge in safety management; The existing occupational safety and health framework is fragmented; No SSS, SHO, or safety leader (Zhang et al., 2018). Among the method factors, methods to improve OHS performance indicators of construction contractors, measure the performance of contractors, and the safety management of the whole workplace is one of the topics of OHS management (Han et al., 2015; Shen et al., 2020; Trethewy, 2003). In terms of environmental and climatic factors, the impact of climate change on outdoor workers and their safety is very important (Maqbool et al., 2020; Moda et al., 2019). In particular, the World Health Organization (WHO) and the International Labour Organization (ILO) are developing a joint methodology to estimate the national and global burden of work-related diseases and injuries (the WHO/ILO joint methodology) (Madgwick et al., 2011; Marinaccio et al., 2019; Messeri et al., 2019; Paulo et al., 2019), especially on the management and control of safe climate factors (Oah et al., 2018; Umar and Egbu, 2018). Some studies believe that construction noise also has a great impact on workers' health (Li et al., 2016). In the spring of 2020, because construction noise complaints accounted for 36% of all noise complaints during the COVID-19 in the London area, measures for surrounding noise protection and personal wear protection were proposed (Tong et al., 2021). It can be seen that there are many influencing factors of OHS and the relationship is complex. Therefore, the new influencing factors brought about by the background of COVID-19 will inevitably bring more uncertainty, which needs in-depth study and discussion (Gedik et al., 2020; Wang et al., 2021).

The structural equation model (SEM) is also called the latent variable model (LVM). SEM involves linear structural relationship models, covariance structure analysis, latent variable analysis, confirmatory variable analysis, simple LISREL analysis, etc. Generally speaking, structural equation models belong to the category of advanced statistics and belong to multivariable analysis. It integrates two statistical methods: factor analysis and path analysis (Al-Shayea et al., 2019; Badri et al., 2018). SEM is a confirmatory method. Under the premise of theoretical guidance, we must use

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theoretical or empirical rules to build hypothetical model diagrams. SEM analysis software includes LISERL, EQS, and Amos. Amos software is SPSS series software, which is widely used. Amos is also known as covariance structure analysis or causal model analysis (Araya and Sierra, 2021). This study uses the SEM method to verify and evaluate the hypothetical model and puts forward the human-factor causal model based on predecessors, that is, which factors directly or indirectly affect human factors positively or negatively, which is also one of the innovations of this study.

In the constructed human-factor causal model, the sub-factors of human factors are related to other sub-factors, and what kind of hierarchical relationship, this study uses the Chi-squared Automatic Interaction Detection (CHAID) decision tree model for in-depth analysis. The decision tree intelligent discriminant analysis method (Chrysos et al., 2013) is widely used in medical diagnosis, biological analysis, in-depth learning, and optical application analysis, as well as in data comparison analysis and classification importance analysis. In the engineering field, the decision tree is mainly used in equipment improvement, geotechnical engineering novelty analysis, building damage assessment, and engineering modeling. The output field of the CHAID decision tree is especially suitable for classification variables. Its advantage is that it can generate a multi-branched decision tree, and the target variables can be spaced or classified. The branch variables and segmentation values can be determined from the perspective of statistical significance, to optimize the branching process of the tree. Based on the discussion of causality, it can realize the division of many levels of input variables according to the target variables. Therefore, this method is selected to explore the hierarchical relationship among OHS influencing factors (Hussain et al., 2021; Islam et al., 2022; Yigitcanlar et al., 2023).

Based on the impact of COVID-19, this study proposed a hypothetical model based on empirical investigation, verified and evaluated by SEM, and then explored the hierarchical relationship between factors (Ahmed, 2019; Berry et al., 2022; Dennysmith et al., 2021). This study not only tries to combine SEM and CHAID to analyze the relationship between the OHS influencing factors of construction enterprises but also reveals the influence mechanism of various factors under the specific background of COVID-19, to reduce the adverse impact of COVID-19 on the OHS management of construction enterprises and provide solutions (Kwilinski et al., 2022; Nessaibia et al., 2021).

Materials and methods

Research process

The main process of this study is divided into two parts. The first part is the Model assumptions, which consist of the Human causal hypothesis model, Variable design, and Statistical analysis. The second part is the result analysis, which consists of SEM model analysis, CHAID decision tree analysis, and Ishikawa analysis (see *Fig. 1*, Research process).

Human causal hypothesis model

Based on previous studies, this study proposes a hypothetical model (*Fig. 2*). The target factor is the Human, and the source factors are Method, Management, Material, and Environment. The first two factors are directly influencing factors, and the last two factors are origin factors. The four assumptions proposed in this paper are as follows:

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H1: method factors directly affect human factors
H2: management factors directly affect human factors
H3: material factors directly affect management factors
H4: environmental factors directly affect method factors
This paper first verifies the hypothesis model, and then makes an empirical analysis.

Variable design of human factor causal model

Aiming at various influencing factors of OHS in construction enterprises, this paper combines the human-factor causal model (see *Fig. 2*), and Codes the sub-variables of five factors (see *Table 1*). Among them, factor refers to five types of factors, code refers to the code to be used by the SEM method, and describe refers to the description of sub-variables.

Statistical analysis

Scale design and investigation

For questionnaire design (see Data Availability Statement A or Appendix), 259 valid questionnaires were finally collected. Statistical analysis IBM SPSS statistics 23 and structural equation analysis (SEM) Amos graphics 23 were used as data analysis tools (See Data Availability Statement B).

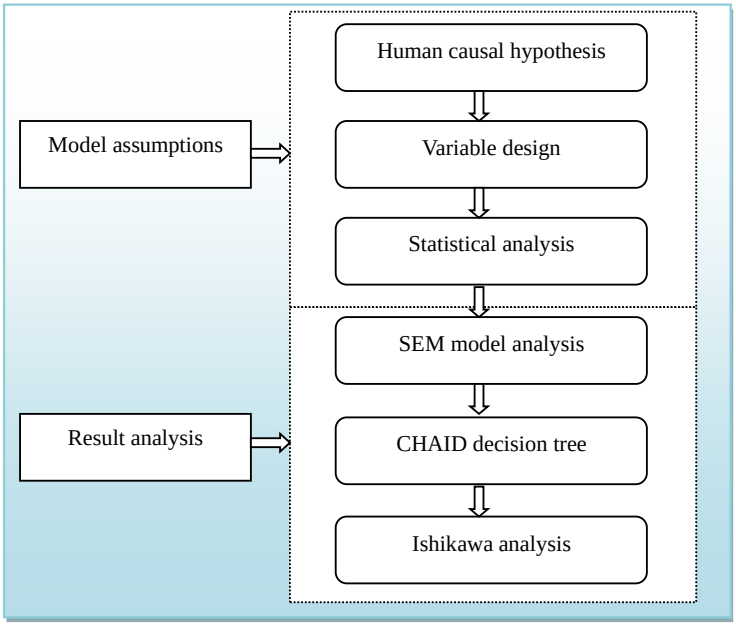

Figure 1. *Research process*

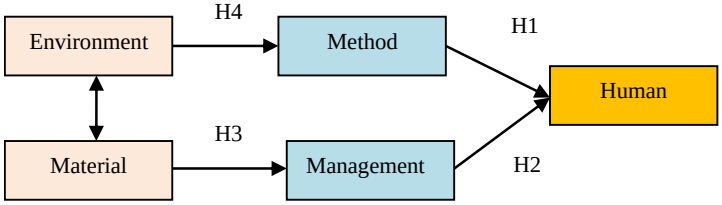

Figure 2. *Human cause model*

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Table 1. *Factors of COVID-19 on OHS in construction enterprises*

Factor	Code	Name	Describe
Human	Q7	Self-confidence	Do you have confidence in China's victory over COVID-19?
	Q8	Psychological counseling	Is it important to set up psychological counseling centers for epidemic prevention and control in enterprises?
	Q9	Pre-job training	Is it important to conduct public health awareness training for new workers?
	Q10	Personnel mobility	How much do the cross-provincial prevention and control measures affect the daily management of employees?
Material	Q11	Epidemic prevention materials	Do flammable and explosive medical reagents, alcohol, etc. pose great risks to epidemic prevention safety?
	Q12	Fire fighting facilities	How important is the inspection and maintenance of fire fighting facilities and equipment to epidemic prevention safety?
	Q13	Electrical equipment	What is the risk of long-term uninterrupted operation of electrical equipment in epidemic areas?
	Q14	Living materials	How important is it to ensure the supply of living materials during the epidemic?
Management	Q15	The legal system	The COVID-19 is force majeure. Do you think it is possible to obtain corresponding compensation from Party A in claim management?
	Q16	Safety management	What is the degree of increased risk of safety accidents due to the impact of the epidemic?
	Q17	Emergency management	Will regular drills and normalized measures to deal with epidemic situations increase the difficulties in emergency management and risk management of engineering projects?
	Q18	Residential health	Does the construction of a policy and system guarantee system for safe and healthy living play a great role in coping with the epidemic?
Method	Q19	Filing management	Does the establishment of the epidemic prevention management manual, "one person, one file" and management measures to ensure accurate information plays a great role in epidemic prevention and control?
	Q20	Remote sharing	Establish remote and big data health screening mechanisms, build remote office digitalization, and adopt a shared service management model. What are the beneficial effects of these means on epidemic prevention and control?
	Q21	Scientific and technological innovation	Does industrialization, intelligence, BIM Technology Simulation, and other new technologies play a great role in the safety of epidemic prevention?
	Q22	Safety control	Does the long-term shutdown during the epidemic bring great potential safety hazards to the construction of large section structures and deep foundation pit retaining structures?
Environment	Q23	Environmental pollution	Does the waste pollution (air, water, dust, etc.) related to epidemic prevention in construction sites have a great impact on the health of employees?
	Q24	Divisional prevention and control	The site is under closed and centralized management to reduce personnel flow and aggregation. The prevention and control management of living areas and canteens (office areas, living areas, and production areas) is under divisional management. Are these measures beneficial to epidemic prevention and control?
	Q25	Healthy buildings	Gradually promote healthy buildings to reduce the risk of cross-diffusion of public health emergencies. Do you think such a promotion is feasible?
	Q26	Fire risk	As for the fire safety of epidemic-related places, have the special closed prevention and control measures increased the fire risk of the places?

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The construction industry practitioners are the survey objects of this study. The survey is conducted through online questionnaires, in which the basic personal information is investigated in the form of a question description, and the specific contents of various factors are investigated in the form of the Likert scale. The age distribution of respondents is 18.92% for those over 50 years old, 31.66% for those between 40 and 50 years old, 30.89% for those between 30 and 39 years old, and 18.53% for those under 30 years old. It can be seen that respondents between 30 and 50 years old are the main subjects of this survey (see *Fig. 3*). 81.08% of the surveyed individuals have university (undergraduate, junior college) degrees (see *Fig. 4*). The proportion of practitioners in construction units is close to 60% (see *Fig. 5*). The proportion of practitioners in the project department (or branch) is about 50% (see *Fig. 6*).

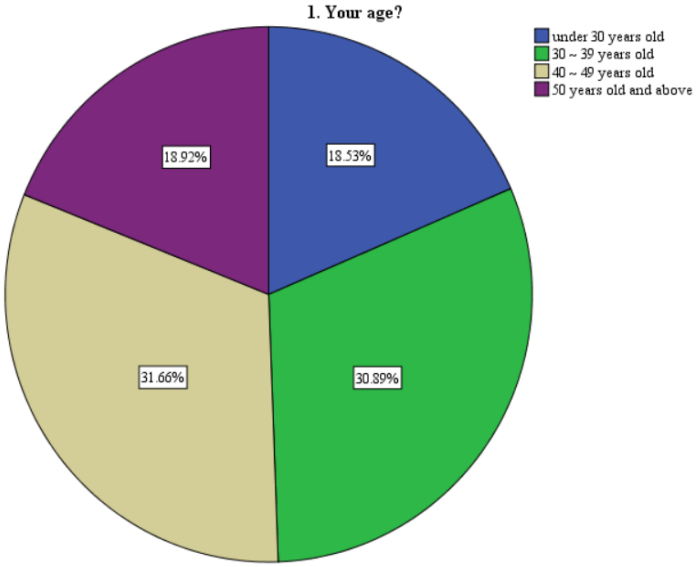

Figure 3. *Frequency of Q1*

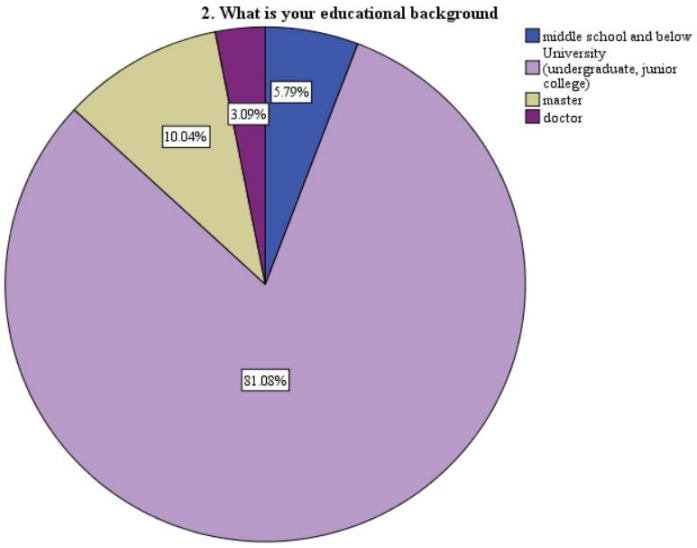

Figure 4. *Frequency of Q2*

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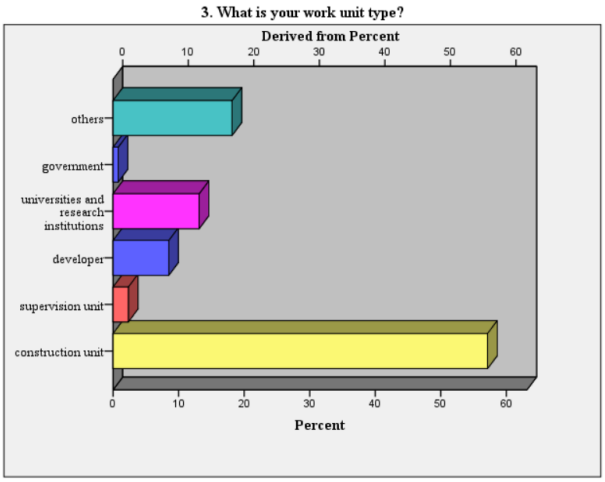

Figure 5. *Frequency of Q3*

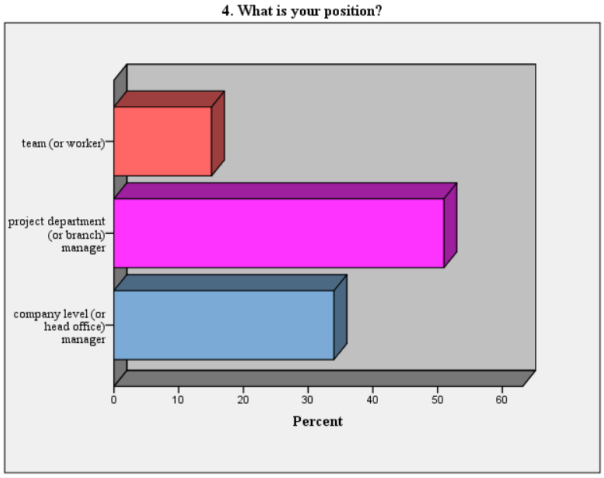

Figure 6. *Frequency of Q4*

Statistical description of the scale

(1) Validity analysis (KMO and Bartlett test)

1. Content validity analysis: Part of the questionnaire in this paper draws on the scales that have been used many times at home and abroad and have good results, while the rest are self-developed. This part of the scale is summarized through the examples of OHS management in construction enterprises. Before the final questionnaire was determined, some contents were modified and improved through discussion with the respondents and relevant experts. Therefore, it can ensure that the questionnaire in this paper has good content validity.

2. Structural validity analysis: Because there are many variables in this model, it is necessary to conduct exploratory factor analysis on the grouping of variables in the model. In this paper, the principal component analysis method of SPSS 23.0 software is used to group the influencing factors, and exploratory factor analysis is carried out respectively. Several principal component factors are forcibly divided, and the variance maximization orthogonal rotation is used for analysis. Before factor analysis, KMO

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(Kaiser-Meyer-Olkin) test and Bartlett sphere test were performed with SPSS 23.0 software to judge whether the variables were suitable for factor analysis. The test results show that (see *Table 2*), The KMO sample test values of all scales are greater than 0.7, and the Bartlett sphere test values are less than 0.001. Therefore, factor analysis can be carried out on the data collected in this paper. And the factor load analysis shows that the convergent validity and differential validity of the questionnaire data are good.

Table 2. *KMO and Bartlett's test*

Kaiser-Meyer-Olkin measure of sampling adequacy		.912
Bartlett's test of sphericity	Approx. chi-square	2400.469
	df	190
	Sig.	.000

(2) Reliability analysis

After exploratory factor analysis, this paper uses SPSS 23.0 statistical analysis software and Cronbach's α Coefficient to check whether the scale has a high degree of internal consistency. The inspection results are shown in the table. The coefficients are all greater than 0.6 (see *Table 3*), Which proves that the reliability of the factors and variables in the questionnaire is high.

Table 3. *Reliability statistics*

Cronbach's alpha	**Cronbach's alpha based on standardized items**	**N of items**
.913	.918	20

Based on the results of the above hypothetical model, the human-factor causal model is effective and reliable and has strong practical significance.

Results

SEM model analysis

SEM design and optimization

SEM modeling is adopted and the data set is input into the model. The simplified measurement model can be obtained by adjusting variables and errors as shown in *Figure 7*. In the model, there are two types of variables, one is an observational variable that can be obtained through interviews or other means of investigation, represented by a rectangle. One type is structural variables, which are variables that cannot be directly observed, also known as latent variables, represented by ellipses. Small circles represent residuals. The unidirectional straight arrow represents the parameter of the regression equation or the factor load of factor analysis. The bidirectional curve arrow represents variance or covariance. The data on the arrow represents the path weight value. The model optimization mainly adopts the following steps: first, input all data into the model, and retain the 2-3 sub-variables with the largest squared multiple correlations: Estimate value among the five types of factors. Then, the Modification Indices: M.I.

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value is optimized and the SEM structure diagram is simplified as much as possible. Finally, if Standardized Regression Weights are within a reasonable range, the model optimization is completed.

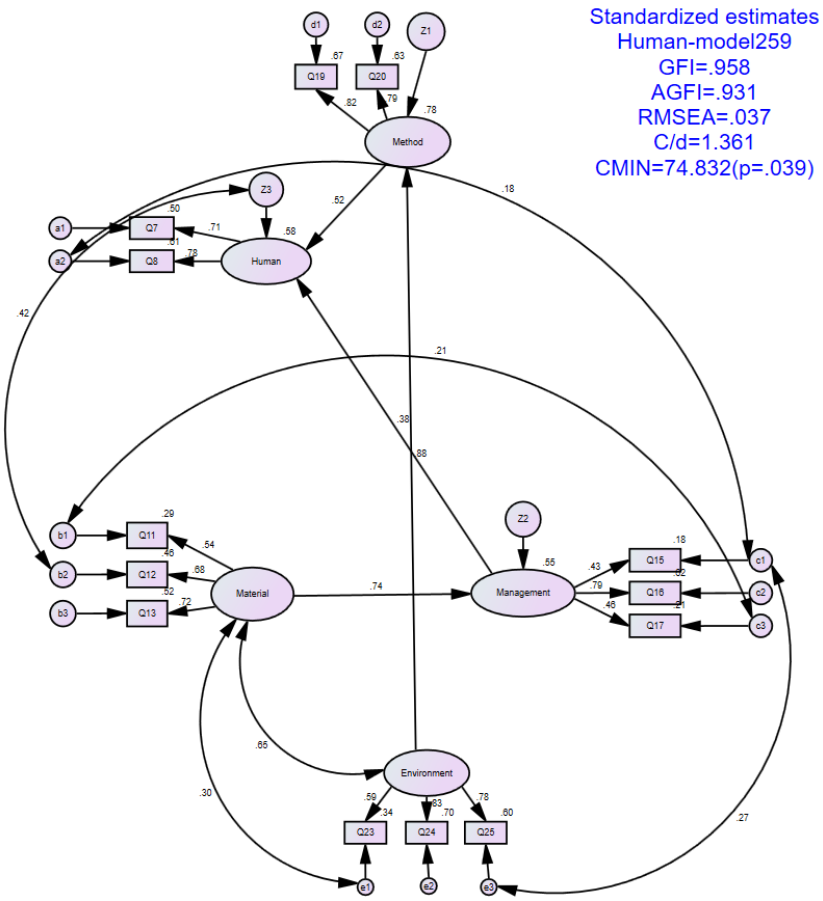

Figure 7. *SEM measurement chart*

Analysis of SEM verification results

It is assumed that the model needs to be analyzed by Standardized Regression Weights and Model Fit Summary to verify the model fitting results.

(1) Standardized regression weights

Analyze the Standardized Regression Weights table of SEM (see *Table 4*.) It can be seen that the Estimate value is between -1 and 1, meeting the requirements for standardized values.

Table 4. *Standardized regression weights: Group number 1 – Human-model 259*

			Estimate
Management	< ---	Material	.743
Method	< ---	Environment	.882
Human	< ---	Method	.518
Human	< ---	Management	.380

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(2) Model fit summary

It can be seen in the Model Fit Summary table (see *Table 5*.) that the CMIN fitting value is small, but because the sample N value is large (259), the p-value is rejected. The GFI value (.958) is greater than the standard value (.90), and the RMSEA value (.037) is less than 0.08, which is acceptable. AGFI value (.931) meets the requirements of 0.90 standard value. The C/d value (1.361) is less than the normal value of 3. Therefore, it is assumed that the fitting result of the model is good.

The following conclusions can be drawn combined with *Tables 4* and *5:*

From the causal weight coefficient between the Method and the Human of 0.581, it can be seen that hypothesis H1 is valid.

From the causal weight coefficient between the Management and the Human of 0.380, it can be seen that H2 is valid.

From the causal weight coefficient between the Material and the Management of 0.743, it can be seen that H3 is valid.

From the causal weight coefficient between the Environment and the Method of 0.882, it can be seen that hypothesis H4 is valid.

It can be seen that the correlation coefficient between the material and the environment is 0.65, so the correlation between these two exogenous latent variables is large (see *Fig. 3*).

Table 5. *Model fit summary*

Parameter	Fitting value	Standard value	N
CMIN	74.832 (P = .039)	The smaller the fitting value, the better (P > 0.05, the larger the sample size, the easier to be rejected)	259
GFI	.958	.90	
RMSEA	.037	.05 (. 08 Acceptable)	
AGFI	.931	.90	
C/d	1.361	3	

CHAID decision tree

SPSS Modeler of CHAID decision tree

Based on the above SEM verification model, it can be seen from the test that only factor self-confidence (Q7) and psychological counseling (Q8) sub-factors can form the decision tree relationship among human factors. To further explore which sub-factors Q7 and Q8 have hierarchical relationships within human factors, the CHAID decision tree model is used for analysis (see *Fig. 8*). IBM SPSS Modeler 18.0 is used in this figure, and Q7 is used as the target factor for modeling (see *Fig. 9* for operation analysis results).

Analysis of CHAID decision tree

Through the analysis of *Figure 9,* it can be seen that the first level tree node of Q7 is Q24, the second level tree node is Q25, and the third level tree node is Q12, that is, self-confidence is most closely related to zoning prevention and control, followed by healthy buildings, and finally related to fire-fighting facilities.

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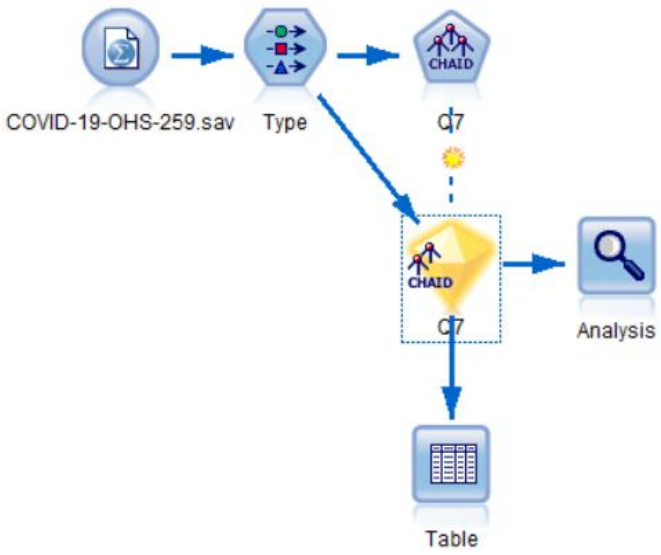

Figure 8. *SPSS Modeler of CHAID decision tree*

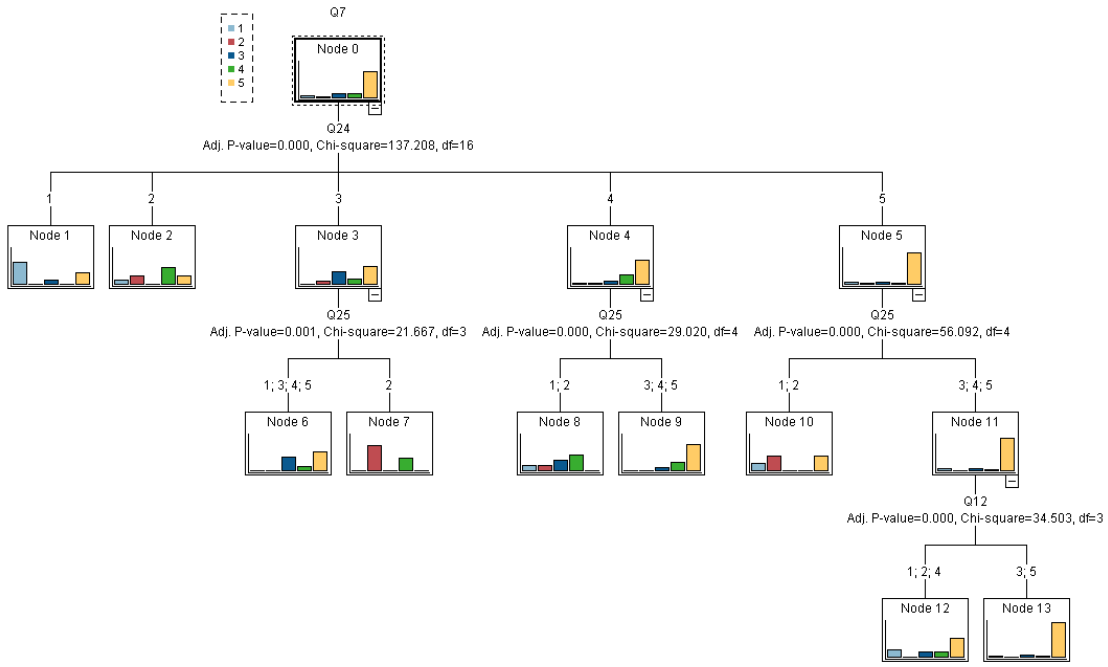

Figure 9. *Q7 of CHAID decision tree chart*

Similarly, according to *Figure 10*, Q8 and Q20; Q12； Q11； Q15, and Q16 are related hierarchically. It is concluded that the first level relationship of the Human factor sub-factors Q7 and Q8 is Q24 and Q20; The second level relationship is Q25 and Q12; The third level relations are Q12 and Q11; The fourth level is Q15 and Q16. That is, the main control sub-factors of Human factors are zoning prevention and control (Q24) and fire fighting facilities (Q12), the secondary control factors are health buildings (Q25) and epidemic prevention materials (Q11), and the general control factors are legal system (Q15) and safety management (Q16).

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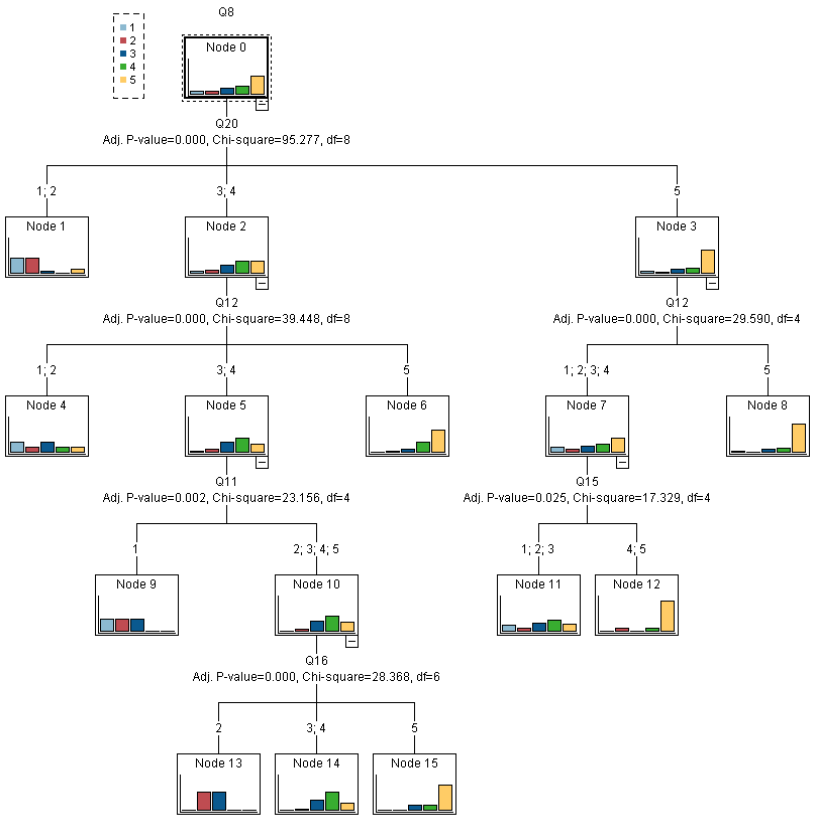

Figure 10. *Q8 of CHAID decision tree chart*

Ishikawa analysis

Ishikawa design

The basis of the above analysis, to show the importance of each factor and its sub-factors, the Ishikawa analysis method (see *Fig. 11*) is used for differential analysis. In this Ishikawa diagram, five factors are analyzed in parallel. The hypothetical relationship here is different from that in *Figure 2*. *Figure 11* does not show the influence relationship between the five factors, but represents the source factor of the Influence factor.

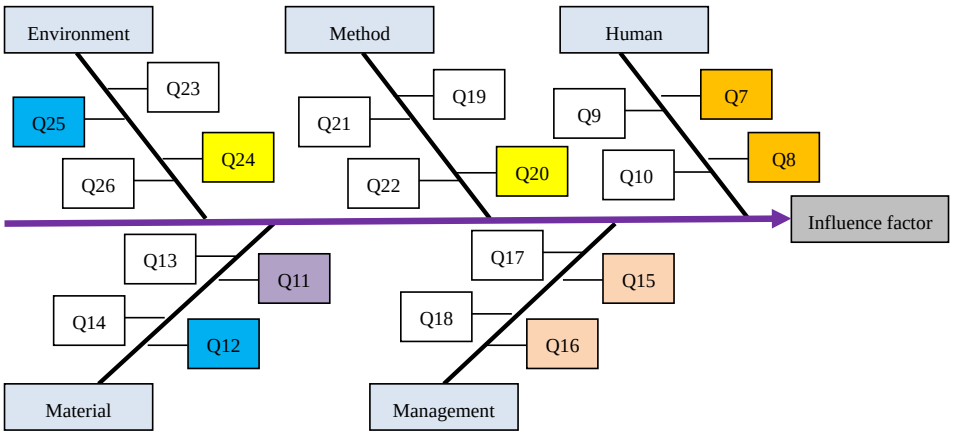

Figure 11. *Ishikawa design*

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Ishikawa results

It can be seen from the above Ishikawa design (see *Fig. 11*) that among the five categories of influencing factors (Environment, Material, Method, Management, and Human), the important sub-factors of Environment are Q24 and Q25, the important sub-factors of Material are Q11 and Q12, the important sub-factors of Method are Q20, the important sub-factors of Management are Q15 and Q16, and the important sub-factors of Human are Q7 and Q8. These sub-factors are the key factors affecting the OHS of construction enterprises in the context of COVID-19. They are the factors that need to be controlled.

Discussion

The research results are in line with the expected assumption that human factors are directly or indirectly affected by many other factors. Surprisingly, this study found that the key sub-factors of five categories of factors, especially the Q7 (self-confidence) and Q8 (psychological counseling) of human factors, belong to human internal psychological factors, which is consistent with the fundamental source factors of Heinrich's causal chain theory of accidents (Majumdar et al., 2022). The other four categories of factors, Environment, Material, and Management all have two key influencing sub-factors, while Method has only one key influencing sub-factor. This shows that not only do the five types of factors have a causal relationship, but also pay attention to the role of sub-factors. This is also a meaningful conclusion drawn from the in-depth analysis of this study.

Past studies have shown that the main factors affecting OHS in the construction industry are job responsibility, training methods, job satisfaction, and working hours, which are significantly different from the factors after the COVID-19 epidemic in this study (Cao et al., 2021a). Based on previous management causal models, this study proposed a human factor causal model. Moreover, since COVID-19 has brought adverse effects on all aspects of construction enterprises, the impact on OHS is particularly serious, which is the new main impact environment of this study (Cao et al., 2021b). Therefore, this study first designed a scale. Based on five factors (human factors, material factors, management factors, method factors, and environmental factors), four questions were designed respectively, and 259 valid questionnaires were collected. The reliability and validity of the questionnaire data were analyzed accordingly, which met the data requirements of constructing an SEM. Therefore, the human-factor model is one of the innovations of this study.

Because the sub-factors of the five factors have different influence weights on the whole hypothetical model, among the optimized results, only the self-confidence factor (Q7) and psychological counseling factor (Q8) has the best effect on the optimization and adjustment of the model, and the sub-factors of other factors have also been optimized accordingly, so the final hypothetical model of human factors is obtained. The model shows that the target factor is the Human factor, and the other factors are the source factor and direct influence factor. To further explore which other sub-factors affect the individual factors of human factors, this study uses the CHAID decision tree method to find the key control factors in the sub-factors of different factors. Moreover, the CHAID decision tree also clearly shows the hierarchical relationship of the control sub-factors. This study successfully constructed the causal model of human factors and found the

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main control sub-factors, secondary control sub-factors, and general control sub-factors. Therefore, the exploration of sub-factors is the second major innovation of this study.

The practical significance of this study lies in not only finding the causal relationship between the five types of factors but also finding the key sub-factors, which are the deep-seated source factors affecting OHS. These key sub-factors can guide the management of construction enterprises and control the risk sources affecting OHS, reduce adverse risks, and improve the management level of enterprises. At the same time, the hypothesis model and factor analysis method and process of this study can also provide a reference for risk management of enterprises in other industries. The main deficiency of this study is that it only finds the static causality of the human-factor causal model, and so is the exploration of sub-factors. Therefore, how to reveal the dynamic influence relationship between various factors and sub-factors is a subject that needs more in-depth research.

Conclusion

Based on the background of COVID-19, this study makes an empirical analysis of the influencing factors of OHS in construction enterprises. Firstly, the hypothetical model of human factors is verified by SEM. On this basis, the CHAID decision tree method is used to explore the sub-factors and the following conclusions are obtained.

Firstly, the causal model of human factors is established and reliable. Human factors are directly and positively influenced by method factors and management factors. Moreover, environmental factors directly and positively affect method factors, and material factors directly and positively affect management factors. That is, environmental factors and material factors are the origin factors and human factors are the target factors.

Secondly, the most critical sub-factors of human factors are Q7 (self-confidence) and Q8t (psychological counseling). The key sub-factors of other factors are Q24 (differential prevention and control) and Q25 (health building); Q11 (epidemic prevention materials), Q12 (fire fighting facilities); Q20 (remote sharing); Q15 (the legal system), Q16 (safety management).

It can be seen that the objective control of human factors in OHS of construction enterprises should be strengthened in the environment of COVID-19, and the management of self-confidence factors and psychological counseling factors should be given priority. At the same time, the control of sub-factors such as zoning prevention and fire-fighting facilities should be strengthened and so would reduce the adverse impact of COVID-19.

Author contributions. Conceptualization, methodology, writing of original draft preparation, supervision, and funding acquisition, Z.H. Cao; formal analysis, data curation, visualization, and project administration, C.P. Ye and T. Zhou; validation, C.P Ye and Z.H. Cao; software, Z.H. Cao and Y.Q. Cao; writing of review and editing, Z.H. Cao and Y.Q. Cao.

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Conflict of interests. The authors declare no conflict of interests.

Data availability statement. A. The datasets [GENERATED/ANALYZED] for this study can be found in [FigShare] [10.6084/m9.figshare.20078621]. B. The datasets [GENERATED/ANALYZED] for this study can be found in [FigShare] [10.6084/m9.figshare.20078645].

Ethics statement. The studies involving man participants were reviewed and approved by the Research Ethics Committee of Wuhan Qingchuan University. The participants provided written informed consent to participate in this study.

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APPENDIX

Questionnaire on Influencing Factors of COVID-19 on Occupational Health and Safety (OHS) in Construction Enterprises

Dear experts,

Hello! First of all, thank you very much for taking the time to participate in this survey! The purpose of this survey is to understand the influencing factors and degree of COVID-19 on the Occupational Health and Safety (OHS) of construction enterprises. There is no right or wrong answer to the question, which only reflects personal intention. This survey is conducted anonymously. The survey data are only used for academic research and will not affect any of your work. Thank you for your support and cooperation! (Tips: There are 27 questions in total, which will take about 5 minutes of your valuable time).

June 5, 2022

I. Basic information

1. Your age? [single choice]
□ under 30 years old □ 30 ~ 39 years old □ 40 ~ 49 years old □ 50 years old and above
2. What is your educational background? [single choice]
□ middle school and below □ University (undergraduate, junior college)
□ master □ doctor
3. What is your work unit type? [single choice]
□ construction unit □ supervision unit □ developer □ universities and research institutions □ government □ others
4. What is your position? [single choice]
□ company level (or head office) manager □ project department (or branch) manager □ team (or worker)
5. Your professional title? [single choice]
□ senior □ vice senior □ intermediate □ junior and below
6. How long have you worked in a construction enterprise? [single choice]
□ less than 2 years □ 2 ~ 5 years □ 6 ~ 9 years □ 10 years and above

II. Questionnaire content

Based on your understanding and experience, please judge the influencing factors and degree of COVID-19 (covid-19) on occupational health and safety (OHS) of construction enterprises from different levels. 1-5 represents the difference in the degree of influence, of which 1 represents the minimum degree of influence and 5 represents the maximum degree of influence.

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A. Human

1. [self-confidence] Do you have confidence in China's victory over COVID-19? [scale questions]
2. [psychological counseling] Is it important to set up psychological counseling centers for epidemic prevention and control in enterprises? [scale questions]
3. [pre-job training] Is it important to conduct public health awareness training for new workers? [scale questions]
4. [personnel mobility] How much do the cross-provincial prevention and control measures affect the daily management of employees? [scale questions]

B. Material

5. [epidemic prevention materials] Do flammable and explosive medical reagents, alcohol, etc. pose great risks to epidemic prevention safety? [scale questions]
6. [fire fighting facilities] How important is the inspection and maintenance of fire fighting facilities and equipment to epidemic prevention safety? [scale questions]
7. [electrical equipment] What is the risk of long-term uninterrupted operation of electrical equipment in epidemic areas? [scale questions]
8. [living materials] How important is it to ensure the supply of living materials during the epidemic? [scale questions]

C. Management

9. [the legal system] COVID-19 is force majeure. Do you think it is possible to obtain corresponding compensation from Party A in claim management? [scale questions]
10. [safety management] What is the degree of increased risk of safety accidents due to the impact of the epidemic? [scale questions]
11. [emergency management] Will regular drills and normalized measures to deal with epidemic situations increase the difficulties in emergency management and risk management of engineering projects? [scale questions]
12. [residential health] Does the construction of a policy and system guarantee system for safe and healthy living play a great role in coping with the epidemic? [scale questions]

D. Method

13. [filing management] Does the establishment of the epidemic prevention management manual, "one person, one file" and management measures to ensure accurate information play a great role in epidemic prevention and control? [scale questions]
14. [remote sharing] Establish remote and big data health screening mechanisms, build remote office digitalization and adopt a shared service management model. What are the beneficial effects of these means on epidemic prevention and control? [scale questions]
15. [scientific and technological innovation] Does industrialization, intelligence, BIM Technology Simulation, and other new technologies play a great role in the safety of epidemic prevention? [scale questions]
16. [safety control] Does the long-term shutdown during the epidemic brings great potential safety hazards to the construction of large section structures and deep foundation pit retaining structures? [scale questions]

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E. Environment

17. [environmental pollution] Does waste pollution (air, water, dust, etc.) related to epidemic prevention in construction sites have a great impact on the health of employees? [scale questions]
18. [divisional prevention and control] The site is under closed and centralized management to reduce personnel flow and aggregation. The prevention and control management of living areas and canteens (office areas, living areas, and production areas) is under divisional management. Are these measures beneficial to epidemic prevention and control? [scale questions]
19. [healthy buildings] Gradually promote healthy buildings to reduce the risk of cross-diffusion of public health emergencies. Do you think such a promotion is feasible? [scale questions]
20. [fire risk] As for the fire safety of epidemic-related places, have the special closed prevention and control measures increased the fire risk of the places? [scale questions]
21. Other influencing factors you think are: [fill in the blank] _____.

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