Xin *et al. BMC Psychology* (2025) 13:375
https://doi.org/10.1186/s40359-025-02700-5

BMC Psychology

RESEARCH Open Access

Development and validation of an information-motivation-behavioral skills questionnaire for colorectal cancer prevention in a high-risk population

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Abstract

Background Colorectal cancer (CRC) is one of the most prevalent cancers, and the risk of CRC is substantially greater in a high-risk population than in the general population. However, no existing assessment instruments have been specifically designed to evaluate CRC prevention behaviors in a high-risk population. The aim of this study was to develop and psychometrically validate an information-motivation-behavioral skills (IMB) questionnaire tailored for the population at high risk for CRC (IMB-CRC) to assess the factors influencing prevention behaviors.

Methods This cross-sectional study was conducted in northeastern China. The initial questionnaire items were derived from a comprehensive literature review, semistructured interviews analyzed via content analysis, and expert focus group discussions. Content validity was assessed through expert consultation using the Delphi method, and face validity was evaluated in the high-risk population for CRC. Explanatory factor analysis (EFA) was performed on Sample 1 ($N=287$) to identify underlying factors, and confirmatory factor analysis (CFA) was performed on Sample 2 ($N=224$) to validate the model. Internal consistency and test-retest reliability were also examined to ensure the stability and consistency of the questionnaire.

Results The final IMB-CRC comprises 21 items distributed across four dimensions: prevention information (7 items), objective skills (5 items), self-efficacy (5 items), and motivation (4 items), collectively accounting for 61.99% of the variance. CFA indicated that the proposed model fit the data well ($\chi 2/df=1.779$, RMSEA = 0.059, AGFI = 0.852, GFI = 0.883, CFI = 0.950, IFI = 0.951, TLI = 0.943, and NFI = 0.894). The item content validity index (I-CVI) for individual items ranged from 0.905 to 1, and the scale content validity index (S-CVI) was 0.952, suggesting good content validity. The IMB-CRC demonstrated high reliability, with a Cronbach's alpha of 0.937, McDonald's omega of 0.939, and test-retest reliability of 0.919. Significant positive correlations were observed between the IMB-CRC and each of its four dimensions, indicating that higher IMB-CRC scores were associated with greater engagement in cancer prevention behaviors among the high-risk population.

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Conclusion The IMB-CRC exhibited appropriate validity and reliability, indicating that this questionnaire is a robust tool for assessing behavioral components essential for CRC prevention in the high-risk population. Health care professionals and policymakers can use the IMB-CRC to develop targeted CRC risk communication and behavioral education strategies, thereby improving the preventive abilities of a high-risk population.

Keywords Colorectal cancer, Prevention, High-risk population, Questionnaire, Reliability, Validity

Introduction

Colorectal cancer (CRC) is the most common cancer with the second greatest mortality rate, imposing a substantial burden on global cancer rates and a serious threat to public health [1]. In 2022, approximately 1,925,828 CRC patients were recorded, resulting in nearly 903,643 deaths according to global cancer statistics [1]. In China, the incidence of CRC is increasing, with approximately 517,000 new cases and nearly 240,000 deaths [2]. CRC has high morbidity and mortality rates, which not only threatens human health but also imposes a considerable burden on society, the medical system, and families [3]. Many studies have demonstrated that a high-risk population for CRC have a significantly greater risk of developing CRC than the general population does; for example, the risk for first-degree relatives is two to three times greater than that of the general population [4, 5]. The percentage of patients with polyps who develop CRC ranges from 5 to 70% [6, 7]. Early CRC prevention is less complex and less expensive than the standard treatments, such as surgery, radiation, chemotherapy, and targeted therapies, which results in longer survival and better quality of life for individuals [8]. Therefore, increasing CRC prevention in high-risk population is imperative to reduce the burden of CRC.

The high-risk population of CRC (such as those with a previous diagnosis of adenomatous polyps and a family history of CRC) may be as susceptible or more susceptible to lifestyle behavior-related risks than the general population is. Adopting cancer prevention behaviors is a protective factor among the high-risk population for CRC [9]; eating a healthy diet, being physically active, maintaining a healthy weight, not smoking or quitting smoking, and limiting alcohol consumption are effective CRC prevention behaviors [10], which have the potential to prevent 20–70% of CRC cases and deaths [11, 12]. For example, a study investigating the relationship between diet quality index scores and CRC risk among 190,949 participants reported a negative correlation, with higher scores associated with a lower CRC risk [13]. Moreover, each 2-hour increase in sedentary time increases the risk of CRC by 8%; however, engaging in physical activity can decrease the risk of CRC by 15% [14]. Some randomized trials have indicated that CRC screening reduces the incidence of CRC by 18–26% and CRC mortality by 22–31% over 10–17 years of follow-up [15–18]. Notably, participants who reported adhering to ≥3 cancer prevention behaviors had a 19% lower CRC risk compared with participants who reported ≤1 behavior [19]. However, the high-risk population for CRC have a limited understanding of the relationship between prevention behaviors and CRC risk, and the adoption of healthy lifestyle behaviors to prevent CRC is suboptimal [20]. For example, a previous study revealed that 51.7% of the high-risk population for CRC smoked, 31% drank alcohol, only 20.2% engaged in regular physical activity, and 16% indicated that they were motivated to visit the hospital for routine check-ups [21]. Individuals at high risk of CRC are receiving increasing attention, since most of this population is impacted by CRC [22]. Reducing the development of CRC-related precancerous events and the resulting premature deaths can be accomplished by early identification of the high-risk population and management of preventive behaviors [23]. Therefore, it is imperative to assess the effect of prevention behaviors and the factors influencing these behaviors in high-risk population for CRC.

Understanding and recognizing the factors involved in CRC prevention behaviors can aid in the development of targeted interventions and appropriate policies for preventing and controlling CRC [24]. A systematic review suggested that the adoption of preventive behaviors among individuals at high risk for CRC is influenced by factors such as health information and knowledge, motivation, self-efficacy, and prevention skills [20]. These high-risk populations lack awareness of CRC prevention behaviors and related factors [25–28] and may even consider early prevention behaviors irrelevant [29]. A previous study demonstrated that the choice of model used to study cancer prevention behaviors is crucial because the model effectively predicts behaviors and moderates the factors that affect these behaviors to elucidate the complexities involved in cancer prevention strategies and highlights the importance of accurate behavior assessment [30]. Several studies have used the health belief model (HBM), the health action process approach (HAPA), the theory of planned behavior (TPB), and the information-motivation-behavioral Skills (IMB) model to examine the factors influencing CRC prevention behaviors [31–33]. The IMB model is one of the most widely used models for understanding and assessing an individual's health-related behaviors [34] and is based on a critical review and integration of multiple health behavior theories [35]. The IMB model explains complex health behaviors relatively simply and identifies the key factors

influencing the implementation and maintenance of adherent behaviors, such as information, motivation, and behavioral skills [36]. Another key difference between the IMB model and other health models is that the IMB model places greater emphasis on the importance of behavioral skills in predicting health behavior [37]. Previous studies have indicated that the combination of skills assessed with the IMB model effectively prevents and manages various chronic conditions, and the model is well suited to explaining cancer prevention behaviors. Examples include cancer screening behaviors [37], cervical cancer vaccination behaviors [38], and liver cancer prevention behaviors [39]. Therefore, the development of an instrument that uses several elements of the IMB model to assess cancer prevention in the high-risk population for CRC is feasible. The IMB model assumes that a knowledgeable person adopts health behaviors when they are motivated and have the skills to accomplish the behaviors and a sense of self-efficacy [40, 41]. Based on the IMB model, we hypothesized that CRC prevention behaviors among the high-risk population for CRC depend on the extent of an individual's understanding of CRC health information, their motivation to participate, and the objective skills and self-efficacy needed to participate.

Most existing instruments for assessing CRC prevention-related behavioral factors are used to assess CRC-related cancer screening perceptions and cultural beliefs, but assessments of other critical behavioral factors, such as Colorectal Cancer Perceptions Scale [42], Colorectal Cancer Screening Adherence Scale [43], Benefits of and Barriers to Colorectal Cancer Screening Scale [44], and Cultural Belief Scales on Colorectal Cancer Screening [45], are lacking. However, previous studies have reported that the high-risk population lack awareness of CRC, possibly because cancer is a taboo topic in Chinese culture, and Chinese people are reluctant to understand it [46]. Owing to the influence of Confucianism on Chinese culture, some behavioral factors related to cancer prevention among Chinese people may differ from those of other countries and regions. Some Chinese people associate cancer with death and fear and therefore avoid talking about it [47]. Furthermore, the occurrence of cancer is believed to be determined by fate and not influenced by behavior, and nothing can be done to reduce the occurrence of cancer [48]. Therefore, developing a comprehensive instrument to measure CRC prevention behaviors using the IMB model within the Chinese cultural background is necessary to evaluate behavior-related elements that motivate the high-risk population to adopt CRC prevention. Additionally, existing instruments, which rarely examine the key elements of prevention behaviors for the high-risk population for CRC, were developed in the overall population. Therefore, an instrument specific to this population will aid health care providers and policymakers in identifying deficits in information knowledge, motivation, and behavioral skills in the high-risk population for CRC.

We aimed to use the IMB model as a theoretical guide for our instrument; the factor structure of the developed instrument was evaluated using exploratory factor analysis, model fit indices were validated via confirmatory factor analysis, and psychometric properties, such as reliability, face validity, and content validity, were assessed. The Information-Motivation-Behavioral Skills questionnaire for colorectal cancer prevention in a high-risk population (IMB-CRC) may be a valid, reliable, and easy-to-understand CRC prevention assessment aiding health care providers and policymakers in assessing the level of cancer prevention in the high-risk population for CRC.

Materials and methods

Design

This study employed a cross-sectional data collection approach to apply a comprehensive methodology to the development and validation of the IMB-CRC in the high-risk population for CRC residing in Northeast China. An overview of the questionnaire development and validation processes is shown in Fig. 1.

Procedure

Trained investigators (three medical students, two clinicians, and two community nurses) used paper questionnaires to interview all participants face-to-face. We collected data at four hospitals (the First, Second, and Fourth Affiliated Hospitals of Harbin Medical University and Harbin Medical University Cancer Hospital) and three community health service centers (Nangang District, Songbei District, and Xiangfang District).

All methods were performed in accordance with the guidelines of the ethics committee and the Declaration of Helsinki. All the participants signed informed consent forms before beginning the survey. The researchers informed the high-risk population in advance of the purpose and procedures of the study, the measures supporting anonymity and privacy protection, the benefits of completing the questionnaire, and the meaning of the answer choices. Participants could withdraw from the study at any time if they did not wish to continue without facing any adverse consequences. After the survey, we offered participants a gift as a reward and provided information and guidance on CRC prevention. The data were kept anonymous and confidential and were used only for study purposes. This study was approved by the Institutional Review Board of the Second Affiliated Hospital of Harbin Medical University (KY2019-193).

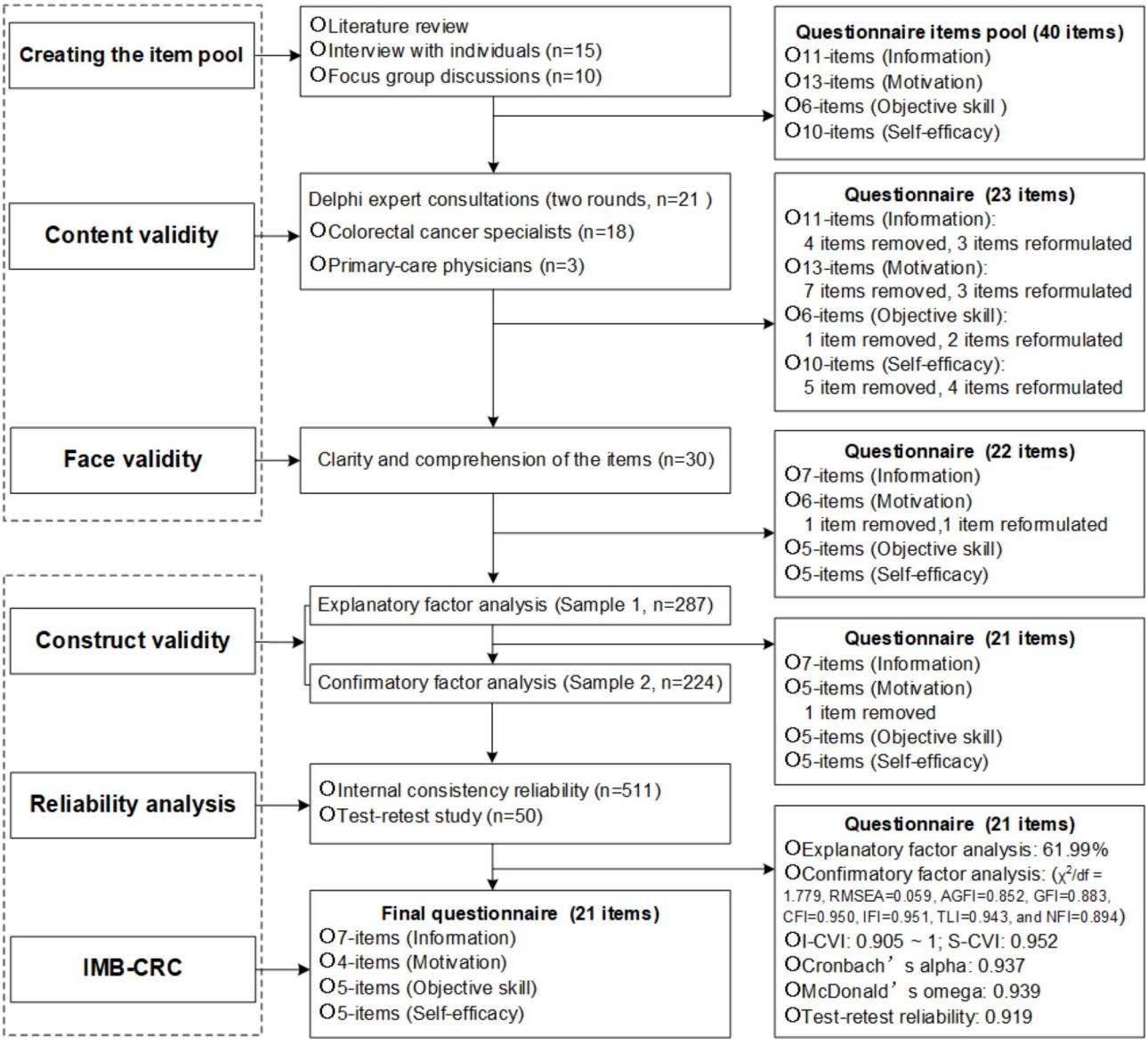

Fig. 1 The overview of the IMB-CRC. Note: IMB-CRC, Information-Motivation-Behavioral Skills Questionnaire for Colorectal Cancer Prevention in a High-Risk Population; I-CVI, item content validity index; S-CVI, scale content validity index; χ2/df, chi-square degree of freedom ratio; RMSEA, root mean square error of approximation; AGFI, adjusted goodness-of-fit index; GFI, goodness-of fit index; CFI, comparative fit index; IFI, incremental fit index; TLI, tucker lewis index; NFI, normed fit index

Participants

The inclusion and exclusion criteria for the study population were based on previous definitions of the high-risk population for CRC and the participant criteria used when developing disease prevention-related questionnaires. The inclusion criteria were as follows: (1) a positive result on the CRC risk assessment tool [49, 50], (2) age ≥ 40 years [51, 52], (3) ability to understand and speak Mandarin Chinese, and (4) willingness to participate. Because the incidence of CRC in China is increasing fastest among 50- to 59-year-olds [53], we included age ≥ 40 years as one of the inclusion criteria for the high-risk population according to the Chinese Guidelines for CRC Screening, Early Diagnosis, and Early Treatment [52]. The exclusion criteria were as follows: (1) a previous CRC diagnosis, (2) an incomplete questionnaire, and (3) communication difficulties that hindered participation. The high-risk population for CRC included individuals who had at least one of the following risk factors according to the CRC risk assessment tool [49, 50]: (1) personal history of colonic polyps; (2) family history of CRC in first-degree relatives; or (3) at least two of the following symptoms or signs: mucous or blood in the stool, major mental trauma or painful events, chronic constipation, diarrhea, appendicitis or biliary disease, and history of appendectomy or cholecystectomy.

Creation of the item pool

First, to design the IMB-CRC, we conducted a comprehensive literature review to gather relevant information and generate an item pool. The literature review was conducted in the PubMed, Embase, PsychINFO, CINAHL, the China Knowledge Network (CNKI), and Wanfang databases. The search keywords included "development", "validation", "colorectal cancer", "colorectal neoplasms", "colorectal carcinoma", "cancer", "prevention", "prevention and control", "behavior", "healthy behavior", "healthy lifestyle", "psychometric", "instrument", "questionnaire", "tool" and "scale". A comprehensive examination of the literature on CRC prevention was performed, focusing specifically on the correlation of cancer prevention and specific behaviors, self-report questionnaires, psychometric indices of the questionnaires (such as reliability and validity) and other instruments employed in this field. The following data were collected for each assessment method: (1) specific items on CRC prevention, (2) different dimensions of CRC prevention behaviors, (3) number and format of items, (4) psychological measurement methods of the questionnaire, and (5) other details of the questionnaire development process (e.g., sample sizes, definitions of experts, intervals of test-retest reliability, and data analysis methods).

Second, we used the IMB model as a theoretical framework to conduct semistructured interviews with 15 participants. We utilized content analysis to elucidate ideas, experiences, and key concepts of CRC prevention among the high-risk population for CRC. The interview included the following questions: (1) "What do you think about CRC prevention?", (2) "What are your motivations for engaging in behaviors for CRC prevention?", (3) "What skills do you think are needed for CRC prevention?", and (4) "What is your experience in adopting CRC prevention behaviors?". The aim of the interview was to generate new information about the ideas and experiences of individuals regarding CRC prevention behaviors to supplement the items on the questionnaire.

Finally, we invited ten gastroenterologists, oncologists, and community health physicians to hold several focus group discussions (FGDs). The questionnaire items were constructed as declarative statements in a simple language style to ensure that the items were easy to understand. After completing the steps described above, the preliminary questionnaire included 40 items in four dimensions, namely, prevention information (11 items), motivation (13 items), objective skills (6 items), and self-efficacy (10 items).

Content validity

Experts in the Delphi process for validation were invited to rate each item on the questionnaire in terms of importance and relevance and to provide recommendations about the questionnaire's scientific rationality, applicability, and readability. The experts rated the importance of the items on a scale of 1 to 5 (1 = very unimportant to 5 = very important), indicating the extent to which they thought each item needed to be included in the IMB-CRC. The experts also scored the relevance of each item on a 4-point Likert scale (1 = not relevant to 4 = fairly relevant). In this study, the relevance of the items was assessed by calculating the content validity index (CVI), which consists of an item-level CVI (I-CVI) and a scale-level CVI (S-CVI).

The experts were chosen according to the following criteria: (1) held significant relevant academic qualifications (e.g., an associate professor/associate chief physician or above) or training in the CRC field, (2) were interested in CRC prevention and had extensive clinical knowledge, and (3) had a minimum of ten years of clinical experience. Finally, 21 experts, including eight experts in oncology (38.10%), five experts in CRC surgical oncology (23.81%), five experts in gastroenterology (23.81%), and three community physicians (14.29%), were invited individually and confidentially via email to form a scientific team. According to the results of two rounds of the Delphi method conducted by the expert panel, 12 items from the initial 40-item pool were revised to improve grammar and wording, and 17 items were removed. After the content validity assessment, the questionnaire consisted of 23 items.

Face validity

To measure the qualitative face validity of the questionnaire, we invited 30 participants to assess the form, comprehensibility, sequence, and fluency of the questionnaire items using a paper version. The assessment measures included (1) which items they had difficulty answering and why, (2) which items they had questions about, and (3) which items they thought should be revised linguistically. To measure the quantitative face validity, the same participants rated each item on a five-point Likert scale ranging from 1 = very unimportant to 5 = very important. We removed one item from the questionnaire that the participants had difficulty understanding. After the face validity assessment, the questionnaire consisted of 22 items.

Construct validity

The construct validity of the questionnaire was assessed using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to determine the extent to which a theoretical trait or concept could be measured [54]. Additional validation data from diverse populations were needed to ensure the validity of the IMB-CRC in different settings. We divided the participants into two independent samples for EFA (Sample 1) and CFA (Sample 2),

depending on their hukou, which ensured a comprehensive examination of the constructs of the questionnaire. The sample sizes met the minimum requirements of five individuals per item for the EFA [55] and more than 200 individuals for the CFA [56].

Reliability

The reliability evaluations used were internal consistency reliability and test–retest reliability. Cronbach's alpha and McDonald's omega were used to measure internal consistency reliability. Temporal stability was evaluated using test-retest reliability in 50 individuals at high risk for CRC. The participants were asked to complete the IMB-CRC again two weeks after the initial survey. The interval of two weeks between tests was considered an appropriate length to avoid recall bias and sample changes [57].

Background questions

The background questions consisted of two sections. The first section included the demographic characteristics of the participants, including age, sex, marital status, education, occupation, residence, household monthly income, body mass index (BMI), smoking, alcohol consumption, and whether they had ever undergone CRC screening. The second section was a CRC risk assessment tool, which included three questions [49, 50].

Statistical analysis

This study used descriptive statistics (e.g., means, standard deviations, percentages) to examine demographic data. The validity and reliability assessments were performed in the following order: (1) Content validity: The discrete tendency was calculated by the coefficient of variation (CV) [58]. An item with a mean importance score > 4.0 and CV < 0.25 was considered to meet the criteria [59]. The total number of experts was divided by those who scored the items as 3 or 4 to calculate the I-CVI, and the S-CVI based on the S-CVI/Avg method [60, 61]. An I-CVI of ≥ 0.80 for an item is recommended to ensure adequate content validity [62], and the acceptable S-CVI/Avg ≥0.90 [63]. (2) Face validity: Impact scores for the items were calculated by multiplying the relative frequency of participants who rated the items as 4 or 5 by the mean importance score for that item. Impact scores > 1.5 were considered acceptable [64]. (3) Construct validity: An EFA was conducted using principal component analysis with varimax rotation [65]. Bartlett's test, Kaiser–Meyer–Olkin (KMO) test, and an eigenvalue cutoff value > 1 were used to evaluate the suitability of the EFA [54]. Items with a total correlation ≤ 0.40, a factor loading ≤ 0.50 for one factor, and a shared loading of two factors were removed [66]. CFA was performed using structural equation modeling (SEM). The fit indices included the chi-square degree of freedom ratio ($\chi 2/df$), tucker lewis index (TLI), root mean square error of approximation (RMSEA), goodness-of fit index (GFI), incremental fit index (IFI), normed fit index (NFI), comparative fit index (CFI), and adjusted goodness-of-fit index (AGFI). The following index values were considered to indicate good fit: $\chi 2/df < 3$ (> 5, poor fit), IFI > 0.90, TLI > 0.90, NFI > 0.90, GFI > 0.90, AGFI > 0.90, CFI > 0.90, and RMSEA < 0.08 [67–69]. (4) Reliability: The internal consistency reliability of the IMB-CRC and the individual dimensions was assessed using Cronbach's alpha and McDonald's omega, with α and omega values ≥ 0.70 indicative of adequate internal consistency for the full questionnaire and each dimension [69, 70]. Test-retest reliability was evaluated using Spearman's correlation analysis. A test-retest reliability ≥ 0.70 was considered acceptable [71]. In this study, SPSS 25.0 was used for the content validity, face validity, EFA and reliability analyses, and AMOS 24.0 was used for the CFA. All tests were two-tailed, and the significance level was set at $\alpha = 0.05$.

Results

General participant characteristics

Among the 580 participants, 511 (88.10%) participants completed the questionnaire, and 69 (11.90%) were excluded because of incomplete data. The mean age of all the participants was 53.76 years (SD = 9.82), and 262 (51.27%) participants were female. Notably, only 136 (26.61%) participants had previously undergone CRC screening, suggesting that the CRC screening rate is relatively low in China. These participants were representative of the high-risk population for CRC and were recruited from various hospitals (59.30%) and community health service centers (40.70%). Sample 1 included 287 (56.16%) participants from Harbin and was used for EFA. Sample 2 included 224 (43.84%) participants from cities other than Harbin and was used for validation via CFA. Table 1 lists the main characteristics of the total sample, Sample 1 and Sample 2.

Content validity

The CVI of the items ranged from 0.905 to 1, and all the items had an I-CVI > 0.90. The S-CVI/Avg was 0.952, indicating that the items had good content validity. The I-CVI and S-CVI/Avg of the IMB-CRC met the criteria for content validity, suggesting that the items are accurate and comprehensive for assessing key risk factors for prevention behaviors in the population at high risk for CRC.

Face validity

In the face validity analysis, the item "Being a part of the high-risk population for colorectal cancer means that my likelihood of developing the condition is greater than that of the general population" was removed because it was confusing and difficult for participants to understand.

Table 1 Characteristics of the high-risk population with CRC

Variable		Total (*N* = 511) n (%)	Sample 1 (*N* = 287) n (%)	Sample 2 (*N* = 224) n (%)
Age (Mean ± SD)		53.76 ± 9.82	54.52 ± 9.74	52.79 ± 9.85
Sex	Male	249 (48.73%)	144 (50.17%)	105 (46.88%)
	Female	262 (51.27%)	143 (49.83%)	119 (53.13%)
Education	Uneducated/elementary school	238 (46.58%)	130 (45.30%)	108 (48.21%)
	Middle school	215 (42.07%)	127 (44.25%)	88 (39.29%)
	College or above	58 (11.35%)	30 (10.45%)	28 (12.50%)
Household Monthly Income	< 2000 yuan	102 (19.96%)	66 (23.00%)	36 (16.07%)
	2000–5000 yuan	313 (61.25%)	164 (57.14%)	149 (66.52%)
	> 5000 yuan	96 (18.79%)	57 (19.86%)	39 (17.41%)
Marital status	Single	25 (4.89%)	3 (1.05%)	22 (9.82%)
	Married	430 (84.15%)	249 (86.76%)	181 (80.80%)
	Widowed	24 (4.70%)	20 (6.97%)	4 (1.79%)
	Divorced	32 (6.26%)	15 (5.23%)	17 (7.59%)
Residence	Rural	111 (21.72%)	61 (21.25%)	50 (22.32%)
	City	400 (78.28%)	226 (78.75%)	174 (77.68%)
Occupation	Mental work	171 (33.46%)	107 (37.28%)	64 (28.57%)
	Manual work	340 (66.54%)	180 (62.72%)	160 (71.43%)
Smoking	Yes	149 (29.16%)	83 (28.92%)	66 (29.46%)
	No	362 (70.84%)	204 (71.08%)	158 (70.54%)
Alcohol consumption	Yes	180 (35.23%)	93 (32.40%)	87 (38.84%)
	No	331 (64.77%)	194 (67.60%)	137 (61.16%)
BMI	< 18.5	41 (8.02%)	17 (5.92%)	24 (10.71%)
	18.5–23.9	287 (56.16%)	174 (60.63%)	113 (50.45%)
	≥ 24	183 (35.81%)	96 (33.45%)	87 (38.84%)
CRC Screening	Yes	136 (26.61%)	85 (29.62%)	51 (22.77%)
	No	375 (73.39%)	202 (70.38%)	173 (77.23%)
Health Service	Hospitals	303 (59.30%)	159 (55.40%)	144 (64.29%)
	Community health service centers	208 (40.70%)	128 (44.60%)	80 (35.71%)
Family history of CRC	Yes	201 (39.33%)	101 (35.19%)	100 (44.64%)
	No	310 (60.67%)	186 (64.81%)	124 (55.36%)
High risk symptoms	Yes	250 (48.92%)	162 (56.45%)	88 (39.29%)
	No	261 (51.08%)	125 (43.55%)	136 (60.71%)
Colonic polyps	Yes	166 (32.49%)	81 (28.22%)	85 (37.95%)
	No	345 (67.51%)	206 (71.78%)	139 (62.05%)

Note: N, number; M, mean; SD, standard deviation; CRC, Colorectal Cancer; BMI, body mass index. High risk symptoms: mucous blood stool, major mental trauma or painful event, chronic constipation, diarrhoea, appendicitis or biliary disease, history of appendectomy or cholecystectomy

The face validity assessment revealed that the remaining 22 items had impact scores > 1.5 (2.847–4.293), confirming the appropriateness of the items.

Construct validity

Exploratory factor analysis (EFA)

In the exploratory factor analysis (Sample 1), the KMO test result was 0.926, and Bartlett's test of sphericity (chi-square, df = 3121.712; $P < 0.001$) indicated that the data were suitable for factor analysis. However, one item (I think colorectal cancer threatens my health) was removed from the analysis because of its low factor loading (< 0.50). The detailed results of the first EFA are shown in Table S1 (Supplementary Material). A second EFA was subsequently conducted; the KMO test result was 0.927, and Bartlett's test of sphericity (chi-square, df = 3057.481; $P < 0.001$) confirmed that the data were suitable for factor analysis. Table 2 shows the four factors that were extracted using factor rotation. The questionnaire included 21 items that met the requirements, and the total variance explained by the four extracted factors was 61.99%. After EFA, the number of items in the IMB-CRC was reduced from 22 to 21. According to the factor loadings and the content of the questions, the items were divided into the four factors as follows: Factor 1, information; Factor 2, objective skills; Factor 3, self-efficacy; and Factor 4, motivation. The percentage of variance explained by each factor was 20.85% for information (7 items), 15.75% for objective skills (5 items), 13.02% for self-efficacy (5 items), and 12.37% for motivation

Table 2 Factor loading matrix of the IMB-CRC

Dimension	Item	Factor. 1	Factor. 2	Factor. 3	Factor. 4
Information	A1: Smoking is a risk factor for colorectal cancer	**0.814**	0.310	0.131	0.041
	A2: Being overweight is a risk factor for colorectal cancer	**0.768**	0.071	0.239	0.118
	A3: Heavy alcohol consumption is a risk factor for colorectal cancer	**0.762**	0.372	0.106	0.090
	A4: High-fat and high-sugar diets are risk factors for colorectal cancer	**0.735**	-0.066	0.081	0.326
	A5: A sedentary lifestyle is a risk factor for colorectal cancer	**0.693**	0.271	0.212	0.214
	A6: Colorectal-related conditions are risk factors for colorectal cancer	**0.648**	0.371	0.135	0.220
	A7: Family history is a risk factor for colorectal cancer	**0.590**	0.450	0.063	0.160
Objective skills	B1: I can identify the authenticity of colorectal cancer prevention information	0.348	**0.700**	0.188	0.147
	B2: I can judge the behaviors that lead to colorectal cancer	0.237	**0.689**	0.205	0.133
	B3: I can recognize the risk symptoms of colorectal cancer	0.323	**0.680**	0.253	0.131
	B4: I can turn prevention information into actual behaviors	0.327	**0.645**	0.270	0.148
	B5: I can adopt healthy behavior approaches to prevent colorectal cancer	0.004	**0.549**	-0.054	0.120
Self-efficacy	C1: I can insist on keeping a normal weight	0.058	-0.124	**0.845**	0.035
	C2: I can keep up with regular colorectal cancer screening	0.319	0.277	**0.641**	0.238
	C3: I can adhere to eating healthily	0.074	0.189	**0.639**	0.244
	C4: I can maintain a positive emotional state	0.182	0.255	**0.593**	0.225
	C5: I can stick to physical exercise	0.315	0.421	**0.550**	0.128
Motivation	D1: The high risk of colorectal cancer motivates me to adopt prevention behaviors	0.112	0.059	0.061	**0.769**
	D2: My relatives and friends think I should adopt healthy behaviors to prevent colorectal cancer	0.163	0.165	0.145	**0.717**
	D3: If I fail to take prevention behaviors, it may lead to an increased risk of developing colorectal cancer	0.204	0.169	0.229	**0.704**
	D4: The concept of personal responsibility for health motivates me to engage in colorectal cancer prevention behaviors	0.213	0.279	0.307	**0.685**

Note: IMB-CRC, Information-Motivation-Behavioral Skills Questionnaire for Colorectal Cancer Prevention in a High-Risk Population; Factor 1, information; Factor2, objective skills; Factor 3, self-efficacy; Factor 4, motivation

Table 3 CFA goodness fit index

Index	χ2/df	RMSEA	AGFI	GFI	CFI	IFI	TLI	NFI
Observed	1.779	0.059	0.852	0.883	0.950	0.951	0.943	0.894
Acceptable Range	< 3	< 0.08	> 0.90	> 0.90	> 0.90	> 0.90	> 0.90	> 0.90

Note: CFA, confirmatory factor analysis; χ2/df, chi-square degree of freedom ratio; RMSEA, root mean square error of approximation; AGFI, adjusted goodness-of-fit index; GFI, goodness-of fit index; CFI, comparative fit index; IFI, incremental fit index; TLI, tucker lewis index; NFI, normed fit index

(4 items). These findings illustrate that the items of the IMB-CRC can be categorized into four specific dimensions, which confirms that the predefined concepts of the questionnaire are highly consistent and relevant to each group of variables and that the questionnaire is valid as designed.

Confirmatory factor analysis (CFA)

Confirmatory factor analysis (Sample 2) was performed to determine whether the underlying structure of the 21-item, four-factor model was empirically supported. The fit indices demonstrated that the fit of the four-factor model to the data was excellent: $\chi 2/df = 1.779$ ($\chi 2 = 325.567$, $df = 183$, $P < 0.001$), RMSEA = 0.059, AGFI = 0.852, GFI = 0.883, CFI = 0.950, IFI = 0.951, TLI = 0.943, and NFI = 0.894. Table 3 shows the factor loadings and fit indices. The final version of the IMB-CRC consisted of four factors—information, objective skills, self-efficacy, and motivation—consistent with the dimensions of the IMB model. CFA confirmed the existence of the four factors and their relationships with the 21 questionnaire items. The results are shown in Fig. 2.

Reliability

Internal consistency reliability

In the internal consistency reliability analysis, Cronbach's alpha and McDonald's omega for the total questionnaire were 0.937 and 0.939, respectively. Both indices were > 0.80 for the full questionnaire and each of its dimensions, indicating that the final IMB-CRC has good internal consistency reliability (Table 4). Furthermore, significant positive correlations were observed between the questionnaire and each of the four dimensions (Table 5).

Test-retest reliability

In the test-retest reliability analysis, 50 participants completed the questionnaire a second time after a two-week interval. The test-retest reliability value of the full IMB-CRC questionnaire was 0.919, and the test-retest

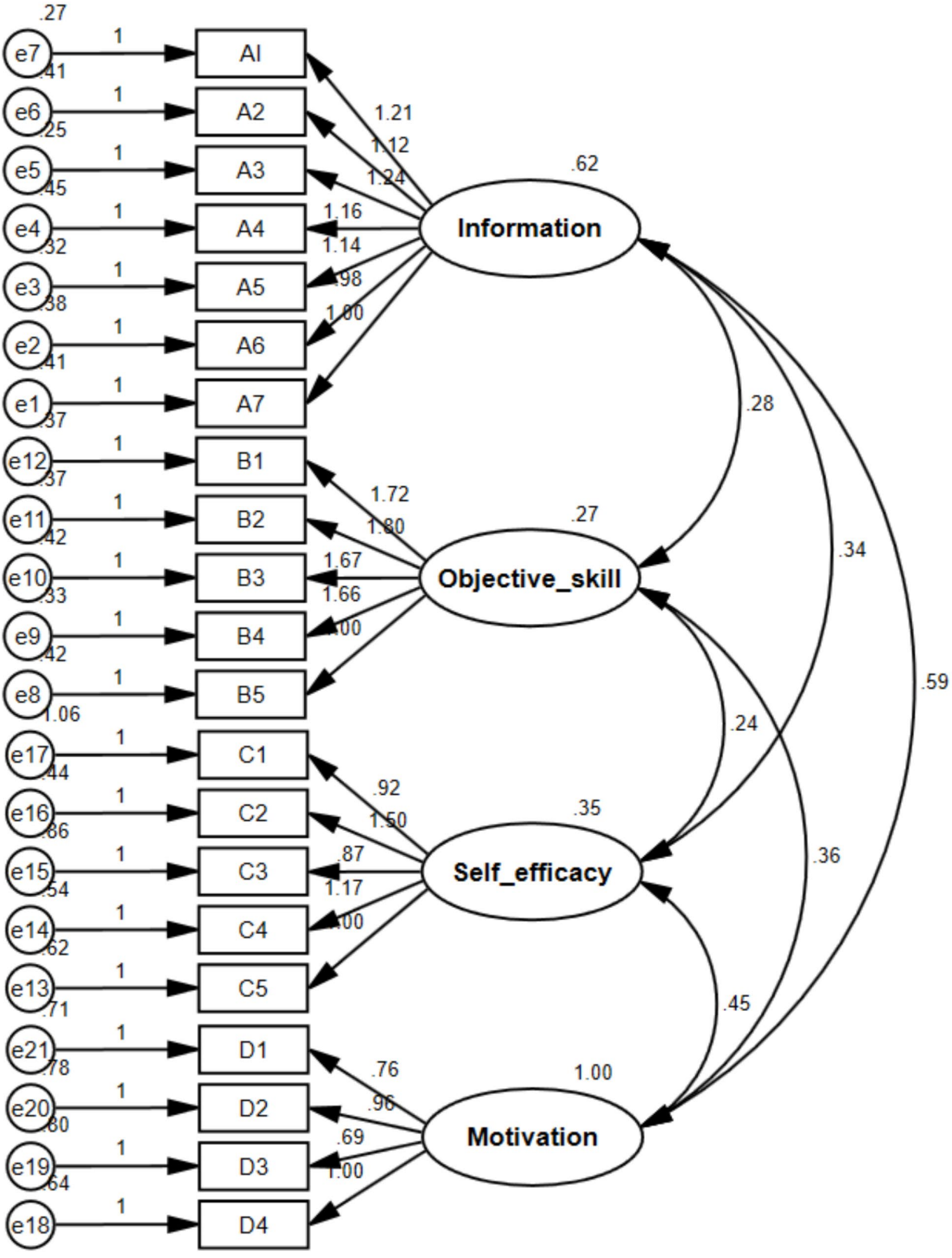

Fig. 2 Standardized factor loadings of the measurement model of the final IMB-CRC. Note: IMB-CRC, Information-Motivation-Behavioral Skills Questionnaire for Colorectal Cancer Prevention in a High-Risk Population

Table 4 The internal consistency reliability of the IMB-CRC

Dimension	Cronbach's alpha	McDonald's omega
Information	0.916	0.933
Objective skills	0.878	0.893
Self-efficacy	0.828	0.852
Motivation	0.801	0.870
IMB-CRC	0.937	0.939

Note: IMB-CRC, Information-Motivation-Behavioral Skills Questionnaire for Colorectal Cancer Prevention in a High-Risk Population

Table 5 Correlation between dimensions and their correlation with the IMB-CRC

Dimension	Information	Objective skills	Self-efficacy	Motivation	IMB-CRC
Information	1.000	—	—	—	—
Objective skills	0.626**	1. 000	—	—	—
Self-efficacy	0.519**	0.555**	1. 000	—	—
Motivation	0.529**	0.503**	0.519**	1. 000	—
IMB-CRC	0.859**	0. 815**	0.772**	0.750**	1.000

Note: IMB-CRC, Information-Motivation-Behavioral Skills Questionnaire for Colorectal Cancer Prevention in a High-Risk Population; *$P<0.05$ (two-tailed); **$P<0.01$(two-tailed); ***$P<0.001$(two-tailed)

reliabilities of the dimensions were 0.722 for information, 0.896 for motivation, 0.937 for objective skills, and 0.936 for self-efficacy. These findings indicate that the IMB-CRC has high test-retest reliability, which ensures the temporal stability of the assessment.

The final IMB-CRC

After completing the validation steps, the final version of the IMB-CRC questionnaire consisted of 21 items in four dimensions, as shown in Table S2 (Supplementary Material). In detail, Domain 1 comprises seven items related to awareness of CRC prevention information, Domain 2 has five items associated with objective skills, Domain 3 includes five items related to self-efficacy, and Domain 4 contains four items pertaining to prevention motivation. The total raw scores of the IMB-CRC range from 21 to 105. The final Chinese version of the IMB-CRC can be found in Table S3 (Supplementary Material).

Discussion

Scientific and normative development and validation of the IMB-CRC

The IMB-CRC included 21 items in four dimensions, was developed to measure the factors influencing cancer prevention behaviors among the high-risk population for CRC in China. We adhered to established procedures and standards in psychological measurement for the evaluation of prevention behaviors in the high-risk population for CRC using the IMB model, increasing the validity and reliability of the model and its applicability and effectiveness in cancer prevention. First, multiple methods were performed for item pool construction, including a literature review, interviews, and a focus group of health care professionals. The items were optimized through an extensive literature review on cancer prevention and by encouraging the high-risk population for CRC to share their ideas and experiences of preventive behaviors. The experts were clinicians and nurses who had substantial experience in colorectal cancer treatment and care, and primary care physicians who were involved in cancer prevention research and practice. The experts combined their theoretical and practical experiences to provide authoritative recommendations for the IMB-CRC. Second, the psychometric evaluation employed a comprehensive approach including content validity, face validity, construct validity, internal consistency reliability, and test-retest reliability, ensuring the scientific rigor and validity of the questionnaire.

Satisfactory validity and reliability of the IMB-CRC

The IMB-CRC had satisfactory reliability and validity in effectively assessing cancer prevention behaviors in the high-risk population for CRC. The experts reached a satisfactory agreement on I-CVI (≥ 0.90) and S-CVI (0.952), which suggests good content validity [62]. We evaluated the face validity of the IMB-CRC via qualitative and quantitative methods, and the results suggested that the items were highly comprehensible. The concise design and straightforward language make the questionnaire user friendly and quick to complete. EFA resulted in a well-fit four-factor model with good validity that was consistent with the IMB model; this model comprised 21 items in four dimensions, accounting for 61.99% of the variance. CFA was subsequently performed, which confirmed the four-factor structure of the IMB-CRC and demonstrated a good fit [67–69]. The actual measurement results corresponded to the theoretical simulation. Moreover, we tested the internal consistency reliability of the IMB-CRC using Cronbach's alpha and McDonald's omega. Both Cronbach's alpha and McDonald's omega were greater than 0.80 for the IMB-CRC and each of the four dimensions, demonstrating good internal consistency of each dimension [69, 70]. The test-retest reliability of the dimensions was acceptable, with all four dimensions ≥ 0.70, indicating that temporal stability was good [69]. Therefore, the IMB-CRC can be used to effectively and scientifically evaluate the essential factors of CRC prevention behaviors, and this model is operationally sound and suitable for clinical and community cancer preventive care practices.

Theory-based IMB-CRC among the high-risk population for CRC

Despite growing evidence of an association between healthy prevention behaviors and a decreased risk of CRC, awareness of prevention behaviors among the high-risk population remains low [72], and these populations do not actively engage in risk-reduction behaviors [21]. In addition, no existing theory-based assessment instruments are available to evaluate key behavioral factors in the high-risk population for CRC. The IMB model, which includes information, motivation, and behavioral skills, has recently become one of the most widely applied health behavior theories [35, 73] and may be a practical, simple theory that can be used for identifying and targeting the determinants of CRC prevention behaviors. The IMB model was initially applied to high-risk population (e.g., individuals with AIDS) and could be used to explain factors that influence health behaviors [74]. On the basis of the IMB model, previous studies have developed the Metabolic Syndrome Health Behavior Questionnaire [75], the Diabetes Self-Management Questionnaire [76], and the HIV Patient Treatment Adherence Questionnaire [77] and explored the factors influencing self-management of behaviors of patients with osteoporosis [35]. The assessment instruments developed using the IMB model as a theoretical framework had good reliability and validity, which indicated the theoretical soundness of the development of the IMB-CRC in this study. Therefore, based on the IMB model, the IMB-CRC is a comprehensive assessment of the key behavioral factors of a high-risk population for CRC, providing valuable insights for CRC prevention research and practice.

Practical implications of the IMB-CRC in the high-risk population for CRC

Previous studies have shown that people who are more knowledgeable about CRC risk factors and prevention methods are more likely to adopt cancer prevention behaviors [78]. The information dimension of the IMB-CRC includes simple and easy-to-understand items, which can help the high-risk population understand CRC risk factors. The measurement of prevention knowledge using the items in this dimension allows health care professionals to determine the knowledge weaknesses of the high-risk population and develop personalized educational materials and targeted programs on CRC prevention in clinical and community settings. The IMB-CRC behavioral skills dimension is divided into two subdimensions, self-efficacy for cancer prevention behaviors and the objective ability to use skills to improve cancer prevention, which is the same categorization used in the pioneer study by Fisher [79].The assessment of the behavioral skills dimensions can help health care professionals identify CRC prevention objective skills that are lacking in the high-risk population and implement tailored instruction and self-efficacy support. Individuals with greater health beliefs and motivations are more likely to accept and adopt CRC prevention behaviors than those with weaker beliefs/motivations [80]. Health motivation positively influences the propensity of individuals to adopt protective health behaviors against CRC [21]. To promote CRC prevention behaviors, health care professionals should assist the high-risk population in developing appropriate motivations for prevention and disseminate more useful cancer information and skills. Additionally, policymakers can use the IMB-CRC to aid in designing social-based interventions that provide information, motivation, and behavioral skills support for cancer prevention through various channels, such as advertising, educational sessions, and mobile health apps, for people making healthy choices and adopting CRC prevention behaviors. In summary, utilizing the IMB-CRC can facilitate the development of targeted interventions aimed at preventing cancer and promote the adoption of healthy behaviors among the high-risk population.

Limitations

While the IMB-CRC had strong reliability and validity, certain areas for improvement should be acknowledged. First, the absence of an established gold-standard psychometric instrument to compare against the IMB-CRC restricts conclusions about criterion validity, and the results should be interpreted with caution. Second, CFA suggested that the overall fit of the questionnaire was ideal, but several individual indicators were slightly below the good fit values. Additional samples are needed to analyze the fit of the questionnaire structure further with the theoretical model. Third, this study was a cross-sectional study; therefore, longitudinal studies assessing the evaluation of CRC prevention behaviors and their critical factors using the IMB-CRC are necessary. Finally, given that the sample was predominantly from Northeast China, the findings may not be generalizable to a more diverse high-risk population for CRC. Future studies could address this limitation by including more diverse populations to enhance applicability and generalizability.

Conclusions

The findings of this study demonstrated that the final version of the 21-item IMB-CRC has high internal consistency reliability, temporal stability, and validity for measuring the factors influencing CRC prevention behaviors in the high-risk population. The IMB-CRC offers an operationally reasonable evaluation instrument enabling health care professionals to plan targeted educational and intervention campaigns to increase awareness of prevention behaviors among the high-risk population

for CRC in clinical and community cancer prevention practices. Further testing of the IMB-CRC is recommended to assess its practicability, generalizability and applicability to other populations.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40359-025-02700-5.

Supplementary Material 1

Acknowledgements
The research team greatly appreciates the funding support. The authors wish to thank the second Affiliated Hospital of Harbin Medical University, the Fourth Affiliated Hospital of Harbin Medical University, the Harbin Medical University Cancer Hospital, the First Affiliated Hospital of Harbin Medical University. Additionally, Bo Xin would like to thank Shiyu Wang, who has given her spiritual backing and statistical assistance during research.

Author contributions
B.X. contributed to conceptualisation, data curation, formal analysis, software, project administration, methodology, writing - original draft, writing–review & editing. Q.l. Z. contributed to conceptualisation, data curation, methodology, methodology. D. C. contributed to conceptualisation, data curation, methodology. D.X. M. contributed to conceptualisation, data curation, methodology. H. S. contributed to methodology, methodology. W.H. J. contributed to conceptualisation, methodology, project administration, supervision, writing - review & editing. The author(s) read and approved the final manuscript.

Funding
(1) Harbin Medical University Postgraduate Research and Practice Innovation Project (YJSKYCX2019-96HYD); (2) China Association for Science and Technology Postgraduate Science Popularization Ability Promotion Project (KXYJS2022077); (3) National Social Science Fund of China (22BGL253); (4) Social Science Foundation of Shaanxi Province (2025YB0223); (5) Social Science Foundation of Xi'an (24FZ36).

Data availability
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the 2nd Affiliated Hospital of Harbin Medical University Institutional Review Board (Harbin, Heilongjiang, China, approval number KY2019-193). All methods were implemented in accordance with the Declaration of Helsinki. All participants were invited to participate voluntarily, and informed consent was obtained from all participants, and the right to withdraw at any time. The anonymity and confidentiality of the responses were protected during the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Conflict of interest
The authors declare that they have no conflicts of interest.

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Received: 13 March 2024 / Accepted: 4 April 2025
Published online: 12 April 2025

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