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Construction of risky sexual behaviors intervention program for college students based on Behavior Change Wheel theory: A mixed-methods study



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ABSTRACT

Background: Risky sexual behaviors (RSBs) among college students pose a substantial threat to both physical and mental health and are associated with sexually transmitted infections and unintended pregnancies. However, many existing interventions demonstrate limited sustainability in achieving lasting behavioral change.

Objective: This study aimed to develop a theory-driven, evidence-based intervention program to reduce RSBs among college students in China.

Study design: A sequential mixed-methods study design was employed.

Methods: Program development was guided by the Behavior Change Wheel (BCW) and conducted in two phases. Phase 1 involved developing a preliminary intervention draft informed by a systematic literature review and semi-structured interviews with college students who reported RSBs, with the aim of identifying barriers and facilitators mapped to the Capability, Opportunity, Motivation-Behavior (COM-B) model. Phase 2 consisted of a two-round Delphi consultation with multidisciplinary experts to evaluate and refine the program. Data were analyzed using thematic analysis and descriptive statistics, including the authority coefficient and Kendall's coefficient of concordance (W).

Results: The literature review identified 1893 records, of which 21 studies were included in the synthesis. Fifteen students participated in qualitative interviews, generating three themes and eight subthemes that mapped directly onto COM-B components. Thirteen experts completed both rounds of the Delphi consultation, yielding a 100% response rate and a high authority coefficient (Cr = 0.819). Kendall's W increased from 0.313 (Round 1) to 0.437 (Round 2; $P < 0.05$), indicating improved consensus. The finalized intervention program comprises six primary indicators (COM-B domains), 12 secondary indicators (intervention functions), and 39 tertiary indicators (specific activities). The program is delivered as a six-week, group-based peer intervention (90 min per week), integrating education, skills training, and environmental restructuring.

Conclusions: A theory- and evidence-informed intervention program targeting RSBs among Chinese college students was developed and refined through expert consensus. The program provides a structured blueprint for potential implementation in university settings; however, its feasibility, acceptability, and effectiveness should be examined in future pilot and evaluation studies.

Abbreviations: APEASE, Affordability, Practicability, Effectiveness, Acceptability, Side-effects, Equity; B, Barrier; BCW, Behavior Change Wheel; BCT, Behavior Change Technique; C, Control Group; Ca, Judgment basis coefficient; COM-B, Capability, Opportunity, Motivation-Behavior; COM-B-SRHP, Capability, Opportunity, Motivation-Sexual Risk Reduction Program; Cr, Authority coefficient; Cs, Familiarity coefficient; CV, Coefficient of Variation; I, Intervention Group; F, Facilitator; JBI, Joanna Briggs Institute; HIV, Human Immunodeficiency Virus; KTV, Karaoke television entertainment venues; LGBTQ, Lesbian, Gay, Bisexual, Transgender, and Queer; QES, Quasi-experimental Study; RCTs, Randomized Controlled Trials; RSB, Risky Sexual Behavior; SD, Standard Deviation; STI, Sexually Transmitted Infection; W, Kendall's coefficient of concordance

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1. Introduction

Risky sexual behaviors (RSBs) are commonly defined as behaviors that increase an individual's susceptibility to adverse sexual and reproductive health outcomes, including unprotected vaginal or anal intercourse, sex with casual or multiple partners, and sex under the influence of substances such as alcohol or drugs.^{1–3} RSBs remain a critical global public health challenge, particularly among adolescents and young adults. The World Health Organization has reported that individuals aged 15–24 years account for nearly one-third of new HIV infections.⁴ In addition, unintended pregnancies and unsafe abortions—often resulting from unprotected sex—contribute substantially to the overall disease burden in low- and middle-income countries.⁵

With rapid modernization and increasingly permissive social norms, college students are widely recognized as a population at elevated risk of engaging in RSBs.^{6,7} In China, the National College Sexual and Reproductive Health Survey Report indicated that 60.59% of heterosexual college students reported engaging in RSBs; among these students, 40.96% reported using ineffective or no protective measures, and 13.16% reported casual sex or multiple sexual partners.⁸ Another survey found that 58% of college students had never used condoms during sexual activity, and 61.7% reported having multiple sexual partners.⁹ Notably, nearly 17.5% of sexually active female college students reported experiencing an unplanned pregnancy.¹⁰ A meta-analysis further estimated that the prevalence of RSBs among college students was approximately 40% (95% confidence interval, 32%–48%), with substantial variation across countries and regions.¹¹ Collectively, these behaviors pose serious threats to both the physical and mental well-being of college students.

A wide range of interventions has been implemented to reduce RSBs among college students, including school-based sexual health education, community-based programs, mobile- and social media-delivered interventions, and peer-led approaches.^{12–14} However, existing research presents several limitations. First, many interventions primarily focus on improving sexual health knowledge, while insufficient attention is given to the psychological, social, and contextual determinants underlying behavioral change. Second, a substantial proportion of programs lack explicit theoretical guidance, which may limit their capacity to systematically target modifiable behavioral determinants. Third, the majority of studies emphasize short-term outcomes, with limited evidence regarding the sustainability of behavioral effects over time. As a result, although some programs successfully improve sexual health knowledge, such gains do not consistently translate into sustained behavioral change, and rates of RSBs among college students remain high. These limitations suggest that reducing RSBs requires more than information provision alone. RSBs are shaped by complex interactions among individual capability, social influences, environmental constraints, and motivational processes. Without a clear theoretical framework to analyze these determinants, intervention strategies may fail to address the mechanisms driving behavior. Theory-informed behavioral interventions are therefore essential to ensure that program components are aligned with specific, modifiable determinants and that intervention strategies are systematically derived rather than intuitively selected.

The Behavior Change Wheel (BCW) provides a comprehensive, theory-driven framework for the systematic design of behavior change interventions.¹⁵ At its core is the Capability, Opportunity, Motivation-Behavior (COM-B) model, which posits that behavior arises from dynamic interactions among Capability (psychological and physical), Opportunity (social and physical), and Motivation (reflective and automatic). The BCW further links behavioral diagnosis to nine intervention functions and seven policy categories, offering a structured pathway for translating behavioral determinants into targeted intervention strategies. The BCW has been successfully applied to a range of health behaviors, including smoking cessation and condom use. Given the multifactorial and context-dependent nature of RSBs among college students, the BCW is particularly well-suited to capturing the interplay of intrapersonal, interpersonal, and environmental influences through its integrated COM-B framework. In addition, its transparent and

replicable methodology facilitates the development of interventions that are both theoretically grounded and empirically informed.

Therefore, this study aimed to develop a theory-based and evidence-informed intervention program to reduce RSBs among Chinese college students. By systematically addressing key behavioral determinants and contextual influences, the program seeks to provide a structured and practical framework to support universities and healthcare providers in implementing targeted and sustainable strategies for RSB prevention and sexual health promotion.

2. Methods

2.1. Study design

This study employed a sequential mixed-methods design comprising two phases: (1) development of a preliminary intervention draft informed by a systematic literature review, qualitative interviews, and the BCW theoretical framework; and (2) expert consensus building using the Delphi technique.

2.2. Phase 1: Development of the preliminary intervention draft

The preliminary intervention program was developed through an integrative, theory-driven process that systematically synthesized evidence from three sources: a systematic literature review, qualitative interviews, and the BCW theoretical framework.

2.2.1. Synthesis of evidence from literature Review

A systematic search was conducted following the “6S” evidence pyramid model.¹⁶ Databases including PubMed, Embase, the Cochrane Library, Web of Science, CNKI, Wanfang, and VIP were searched from inception to October 23, 2023. Search terms encompassed three core concepts: risky sexual behaviors (e.g., “risky sex,” “unprotected sex,” “multiple sexual partners”), population (e.g., “college student,” “university student”), and intervention (e.g., “intervention,” “program,” “sex education,” “health education”).

2.2.1.1. Inclusion and exclusion criteria. The inclusion criteria were as follows: (1) participants were college or university students; (2) the study evaluated a sexual health intervention or program; (3) outcomes included knowledge, attitudes, behaviors, or condom use; (4) study designs included randomized controlled trials (RCTs), quasi-experimental studies, systematic reviews, or meta-analyses; and (5) the full text was accessible in English or Chinese.

The exclusion criteria were as follows: (1) studies were descriptive in nature (e.g., reviews, case reports, or study protocols); (2) secondary data analyses; (3) duplicate or unpublished publications; (4) if the full text could not be accessed.

2.2.1.2. Study selection and quality assessment. Two researchers independently screened titles and abstracts, extracted relevant data, and assessed methodological quality (Supplementary Table S1). The Cochrane Risk of Bias tool was used to evaluate RCTs, and the Joanna Briggs Institute (JBI) critical appraisal tools were applied to quasi-experimental studies (Supplementary Table S2 and Table S3).^{17,18} As the primary aim of this review was to inform intervention development rather than to generate pooled effect estimates, no quantitative meta-analysis was conducted. Any discrepancies were resolved through discussion or, when necessary, consultation with a third reviewer.

2.2.2. Integration of qualitative data on behavioral determinants

2.2.2.1. Participants and sampling. Purposive sampling was used to recruit undergraduate students from three universities in Daqing City, Heilongjiang Province, between October 2023 and February 2024. The inclusion criteria were: (1) self-reported engagement in at least one RSB during college, defined as unprotected vaginal or anal intercourse, sex with a casual

partner, or sex under the influence of substances such as alcohol or drugs; (2) full-time undergraduate enrollment; (3) ability to communicate clearly and accurately recall personal experiences; and (4) voluntary participation with written informed consent. Students with diagnosed severe mental disorders (e.g., schizophrenia or major depressive disorder) were excluded. The sample size was determined based on the principle of data saturation. Data collection continued until no new themes emerged, indicating sufficient coverage of behavioral determinants.

2.2.2.2. Data collection. Semi-structured interviews were conducted using an interview guide developed in accordance with the COM-B model to explore barriers to and facilitators of RSBs. The guide was organized around the three core domains of Capability, Opportunity, and Motivation, with each question designed to elicit information related to specific behavioral determinants within these domains. Interviews lasted 30–60 min and were audio-recorded with participants' permission; field notes were taken concurrently. Data collection was conducted iteratively, and themes and subthemes emerging from the interviews were systematically mapped back to the COM-B framework to ensure theoretical coherence. The full interview guide, including its alignment with COM-B components, is provided in the Supplementary Materials ([Supplementary Table S4](#)).

2.2.2.3. Data analysis. Interview transcripts were analyzed using an inductive thematic analysis approach within the deductive framework of the COM-B model. The analysis followed a rigorous, multi-step iterative process. First, two researchers independently read and familiarized themselves with the transcripts. Second, line-by-line coding was conducted to generate initial codes, which were subsequently grouped into potential subthemes based on conceptual similarity. These subthemes were then reviewed, refined, and organized into overarching themes aligned with the COM-B components (Capability, Opportunity, and Motivation). Throughout the analytical process, the researchers met regularly to compare coding results, resolve discrepancies through consensus, and further refine the thematic framework. Analytical rigor and credibility were ensured through continuous team discussions until a coherent and agreed-upon thematic structure was finalized. This process identified COM-B-specific determinants of RSBs, which directly informed the development of the intervention program.

2.2.3. Theoretical mapping and intervention function selection

The COM-B-based behavioral diagnosis derived from the qualitative findings was used to select candidate intervention functions within the BCW framework. After identifying candidate intervention functions through the COM-B to BCW mapping process, the Affordability, Practicability, Effectiveness, Acceptability, Side-effects, and Equity (APEASE) criteria were applied to refine the final selection within the university sexual health context, consistent with the BCW guidance.¹⁹ For psychological capability, Education and Training were retained due to strong empirical support, feasibility within existing educational platforms, and high acceptability. For physical capability, Training and Enablement were selected to strengthen behavioral skills and self-regulation capacity, as they are practical to implement and present minimal risk. A detailed mapping matrix was developed to explicitly link each COM-B determinant to corresponding BCW intervention functions and operationalized tertiary indicators, ensuring transparency of the theory-activity pathway ([Supplementary Table S5](#)). Evidence-based intervention components and effective behavior change techniques (BCTs) identified through the systematic literature review served as a repository of candidate activities.²⁰ These activities included peer-led education, interactive skills training (e.g., condom use and sexual negotiation), and engagement through digital platforms.

2.2.4. Draft program formation

Specific intervention content and activities identified from the literature review were designed to operationalize the selected BCW intervention functions and BCTs, while directly targeting behavioral barriers and facilitators identified through the qualitative interviews.

The synthesized draft framework comprised three hierarchical levels: primary indicators (COM-B domains: Capability, Opportunity, and Motivation), secondary indicators (BCW intervention functions, such as education and training), and tertiary indicators (such as specific intervention activities and content) ([Supplementary Materials, Table S6](#)).

2.3. Phase 2: Expert consensus via the Delphi method

2.3.1. Expert panel composition

Experts were purposively recruited from the fields of sexual health education, nursing, clinical medicine, psychology, and university student administration. To enhance representativeness and minimize potential selection bias, efforts were made to ensure geographic and institutional diversity in the recruitment process. Experts were drawn from multiple regions and a range of institutional settings, including universities, hospitals, and public health organizations. Inclusion criteria were as follows: (1) possession of a master's degree or higher; (2) a lecturer-level professional title or above; (3) at least 10 years of relevant professional or research experience; and (4) willingness to participate in two rounds of consultation.

2.3.2. Delphi consultation process

A Delphi questionnaire was developed based on the preliminary draft intervention program. In Round 1, experts rated the importance of each indicator using a 5-point Likert scale (1 = very unimportant, 5 = very important) and provided open-ended qualitative comments. The questionnaire also collected demographic information as well as self-assessments of familiarity with the subject matter and judgment basis. Items with a mean importance score ≥ 4.0 and a coefficient of variation (CV) ≤ 0.25 were retained.²¹ Qualitative feedback was reviewed by the research team, and revisions were made accordingly. The revised questionnaire was distributed in Round 2 for re-rating. The Delphi process concluded after two rounds when expert consensus stabilized. Questionnaires were distributed and returned via email or WeChat over two-week periods, with one reminder issued per round.

2.3.3. Statistical analysis

Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant and expert characteristics. Continuous variables were reported as means \pm standard deviations (SD), while categorical variables were presented as frequencies and percentages. For the Delphi analysis, experts' positive coefficient was expressed as the effective questionnaire response rate. The authority coefficient (Cr) was calculated as the mean of the familiarity coefficient (Cs) and the judgment basis coefficient (Ca). Expert consensus was assessed using the CV for individual items and Kendall's coefficient of concordance (W) to evaluate overall agreement across consultation rounds. Kendall's W was tested using a two-tailed test, with $P < 0.05$ considered statistically significant.

For the Delphi analysis, experts' positive coefficient was expressed as the effective questionnaire response rate. The Cr was calculated as the mean of the Ca and the Cs. Expert consensus was assessed using the CV for individual items and W to evaluate overall agreement across consultation rounds. Kendall's W ranges from 0 to 1, with higher values indicating stronger agreement among experts. In accordance with commonly accepted criteria, W values < 0.3 were considered to reflect low agreement, values between 0.3 and 0.5 moderate agreement, and values > 0.5 strong agreement.²² Kendall's W was tested using a two-tailed test, with $P < 0.05$ considered statistically significant.

2.4. Ethical considerations

This study was reviewed and approved by the Ethics Committee of Harbin Medical University, Daqing Campus (Approval No: HMUDQ20231116201). All procedures were conducted in accordance with the ethical standards of the institutional research committee and the principles of the Declaration of Helsinki (2013 revision). All participants

provided written informed consent prior to participation. To ensure confidentiality, interview recordings were assigned unique identification codes, and all personally identifiable information was removed from the transcripts. Anonymized transcripts and audio files were securely stored on a password-protected and encrypted server accessible only to members of the research team. Given the sensitive nature of the study topic, participants were provided with information on available support resources, including university counseling services and local sexual health clinics. Participants were informed of their right to decline to answer any question, pause the interview, or withdraw from the study at any time without penalty. Interviewers received training to conduct discussions sensitively and to respond appropriately to signs of distress, including terminating interviews and facilitating referrals when necessary.

3. Results

3.1. Phase 1: Development of the preliminary program draft

3.1.1. The results of literature review

The systematic literature search identified 1893 records. After screening titles, abstracts, and full texts, 21 studies were included in the synthesis, comprising five randomized controlled trials and 16 quasi-experimental studies which were presented in [Supplementary Table S1](#).^{13,23–42} The results of the methodological quality appraisal are presented in [Supplementary Tables S2–S4](#). Key effective intervention components identified across the included studies included peer-led education, interactive skills training (e.g., condom use and sexual negotiation), use of digital platforms, and strategies addressing sexual norms and beliefs.

3.1.2. Qualitative findings from student interviews

Fifteen undergraduate students participated in the interviews, including nine males and six females. The mean age of participants was 21.33 ± 1.95 years. Detailed demographic characteristics are presented in [Table 1](#). Thematic analysis conducted within the COM-B framework identified three overarching themes and eight subthemes, reflecting key barriers and facilitators underlying RSBs.

3.1.2.1. Theme 1: Inadequate capability. (1) Subtheme 1: Insufficient sexual health knowledge and practical skills (facilitator of RSBs).

Participants reported gaps in knowledge related to sexually transmitted infection (STI) prevention, contraceptive options, and the correct selection and use of condoms.

P15: “Since it was the first time (having sex), I didn’t have any knowledge in this area and had no experience either, so unprotected sex occurred.”

P9: “I used a condom that did not have sufficient lubrication and was very dry, which caused considerable discomfort throughout the process. In addition, some condoms had an unpleasant smell, with a strong rubber odor. As a result, I did not know how to choose the right condom. Sometimes I could not find a particularly suitable one, and even when I did buy one, I did not really want to use it.”

(2) Subtheme 2: Misinterpretation of attraction and relationships (both facilitator and barrier).

Some participants equated physical attraction with relationship stability, which led to impulsive sexual decisions.

P7: “I knew a girl. She was very well-behaved and attractive, and she was the type I liked. After we got to know each other for a short time, we had sexual intercourse.”

3.1.2.2. Theme 2: Motivation driven by immediate desires. (1) Subtheme 1: Seeking excitement and impulsive decision-making (facilitator of RSBs).

Thrill-seeking and impulsive behavior, particularly in social contexts such as parties, were frequently reported.

P13: “The main thing was to seek excitement, along with a bit of numbness and impulsiveness. They didn’t think about anything else, nor did they express any desire to date. They were simply seeking excitement.”

P7: “At that time, we didn’t use a condom because I was in control and there was no time left. Then I stopped caring. I think it was just a momentary impulse.”

(2) Subtheme 2: Preserving intimate relationships (facilitator of RSBs).

Fear of rejection or relationship conflict sometimes led participants to agree to unprotected sex against their own preferences.

P6: “As soon as we met, he said he wanted to try something new. Actually, I was quite reluctant, but I didn’t want to spoil the atmosphere, so I remained silent. During the process, I felt extremely uncomfortable. After it was over, no one said anything.”

P5: “I was too embarrassed to refuse my partner’s request not to wear it. I was afraid he would think I didn’t like him, so I reluctantly agreed.”

(3) Subtheme 3: Reflection and sense of responsibility (barrier to RSBs and facilitator of change).

Several participants described regret and anxiety following risky encounters, indicating the emergence of reflective motivation.

P11: “After the incident (the one-time sexual encounter), I felt extremely anxious and regretful. At that time, my sense of self-protection had completely vanished. I never want to go through such a thing again in my life.”

3.1.2.3. Theme 3: Constrained Opportunity. (1) Subtheme1: Frequent exposure to high-risk situations (facilitator of RSBs).

Alcohol use, peer influence, and dating applications were commonly associated with RSBs.

P10: “I have always had a habit of drinking alcohol. At that time, we were out having fun together. When we arrived at the hotel, she accompanied me while drinking. After drinking too much, I felt disoriented. The next day, I couldn’t find a condom in the room. It seems that I didn’t wear one.”

P5: “I usually use dating apps such as Tantan, Soul, and Weibo to meet strangers. After chatting, if I think we are a good match, I will arrange a meeting and have sex.”

(2) Subtheme 2: Limited access to sexual health resources and services (facilitator of RSBs).

Embarrassment, inconvenience, and limited awareness hindered access to condoms, HIV testing, and counseling services.

P5: “What I worry about most is being seen by others, especially strangers. If that happens, I probably won’t go.”

P2: “The self-service machine in our school’s health center is located in a relatively concealed place. If you do not go there often, many people probably will not notice it. So I feel it is not very convenient to obtain condoms or HIV test kits.”

(3) Subtheme 3: Stable partners and interpersonal support (barrier to RSBs).

Participants perceived stable relationships and supportive peer networks as protective factors.

P4: “I think safe sexual behavior means having a stable and developing relationship. In that case, I feel there is no problem, and it is relatively safe.”

P1: “When I encounter troubles or difficulties, my friends comfort me. It is very easy to obtain emotional support from them.”

Table 1
Demographic of interviewing students (n = 15).

Num	Gender	Age	Grade	Major
P1	Female	24	Senior	Engineering
P2	Male	24	Senior	Science and engineering
P3	Male	22	Senior	Medicine
P4	Male	19	Sophomore	Medicine
P5	Female	21	Senior	Science and engineering
P6	Female	21	Junior	Others
P7	Male	21	Junior	Agronomy
P8	Female	18	Freshman	Science and engineering
P9	Female	25	Senior	Medicine
P10	Male	20	Junior	Engineering
P11	Male	19	Freshman	Medicine
P12	Male	22	Sophomore	Agronomy
P13	Male	21	Junior	Others
P14	Male	21	Junior	Science and engineering
P15	Female	22	Junior	Engineering

These findings were directly incorporated into refining the preliminary intervention draft to ensure that it addressed context-specific behavioral determinants.

3.2. Phase 2: Delphi expert consultation

3.2.1. Expert demographic characteristics

Thirteen experts completed both rounds of the Delphi consultation. The mean age of the experts was 44.38 ± 8.80 years, with an average of 19.54 ± 9.42 years of professional experience. The panel included five professors, two associate professors, and five lecturers, representing the fields of sexual health education ($n = 7$), nursing ($n = 2$), clinical medicine ($n = 2$), and university student administration ($n = 2$).

3.2.2. Expert engagement and authority

The effective response rate was 100% in both Delphi rounds, indicating strong expert engagement. The overall Cr was 0.819, comprising a Ca of 0.885 and a Cs of 0.785. This value exceeded the commonly accepted threshold of 0.70, demonstrating a high level of reliability in expert judgments.

3.2.3. Consensus levels

In Round 1, item-level coefficients of variation ranged from 0.052 to 0.247. Based on expert feedback, four tertiary indicators were revised, including the addition of an anonymous online discussion platform and the refinement of student commendation formats. In Round 2, the CV range further decreased to 0.052–0.203, indicating improved convergence of expert opinions. W increased significantly from 0.313 in Round 1 to 0.437 in Round 2 (both $P < 0.05$), reflecting strengthened consensus following the revisions.

3.2.4. Expert opinions and modifications

The intervention protocol was iteratively refined across the two Delphi rounds based on predefined decision criteria. Items with a mean importance score < 3.5 (on a 5-point Likert scale) or a CV > 0.25 were considered for revision or deletion. In addition, qualitative feedback provided by experts was systematically reviewed and incorporated when suggestions were deemed conceptually relevant and consistent with the theoretical framework.

In Round 1, five tertiary indicators were modified based on these criteria and expert comments. These revisions included the addition of contact information for sexual health professionals (1.2.3), adjustment of public recognition formats for student achievements (3.1.1), introduction of structured reflection questions (4.2.5), and specification that interactive demonstrations should be led by professional health educators to ensure content accuracy (5.2.3).

In Round 2, items approaching but not fully meeting consensus thresholds were further refined to improve clarity and feasibility. Two additional revisions were made: content emphasizing respect for sexual desires was incorporated (6.2.2), and students were encouraged to present learning outcomes through display boards or videos at the conclusion of the program (6.2.4). Stability of expert ratings between rounds indicated improved consensus. All revisions are summarized in [Supplementary Table S6](#).

3.3. Final intervention program

The finalized Capability, Opportunity, Motivation–Sexual Risk Reduction Program (COM-B–SRHP) comprises six primary indicators, 12 secondary indicators, and 39 tertiary indicators. The program is delivered as a six-week, group-based intervention, with weekly 90-minute sessions facilitated by trained peer educators under professional supervision. Each session integrates multiple BCW intervention functions centered on a thematic focus. A detailed matrix linking COM-B components, BCW intervention functions, and specific intervention activities is presented in [Table 2](#), with the full intervention schedule and content outlined in [Table 3](#).

Table 2
The elements of behavioral change based on the BCW theory.

COM-B component	Barrier (B) or Facilitator (F)	Intervention goals	Intervention function	Behavior change techniques (BCTs)	Policy categories
Psychological capability	Lack of sexual health knowledge and skills (F)	Providing sex-related professional knowledge, skills, and continuous knowledge acquisition	Education Training	Provides information on health benefits, Behavioral exercises	Communication/Marketing, Guidelines
Physical capability	Attractiveness and favorability (F)	Correctly understanding attractiveness	Training Enablement	Behavioral demonstration, Self-monitoring	Guidelines, Service provision
Automatic motivation	Sensation seeking and impulsivity (F)	Identifying sexual impulses and coping strategies ; and establishing and maintaining normal intimate relationships	Persuasion Training Modeling	verbal persuasion, Behavioral exercises and demonstrations	Communication/Marketing, Guidelines, Regulation
Reflective motivation	Maintenance of "intimate relationships " (F)	Enhancing the ability to judge risky sexual behaviors and reflect on their adverse consequences	Incentivization Education	Incentivization, Provides information on health outcomes	Communication/Marketing, Guidelines
Physical opportunity	Reflection and sense of responsibility (B)	Learning to assess and identify sexual risk factors, sudden sexual situations, and corresponding handling methods	Restriction Training	Outcome goal setting, Behavioral exercises	Legislation, Guidelines
Social opportunity	Limited access to resources and services (F)	Providing sexual health service resources; and strengthening peer and interpersonal support	Environmental Restructuring Enablement	Rebuilding the social environment, Imagine success	Environmental/ social planning, Service provision
	Consistent sexual partners and interpersonal support (B)				

Abbreviation: B, Barrier; BCTs, Behavior change techniques; BCW, Behavior Change Wheel; COM-B, Capability, Opportunity, Motivation-Behavior; F, Facilitator.

Table 3
The final Capability, Opportunity, Motivation-Sexual Risk Reduction Program (COM-B-SRHP).

Primary Indicators (COM-B Component)	Second Indicators (Intervention Function)	Week & Theme	Tertiary Indicators (Key Intervention Contents)	Delivery Mode	Duration
Psychological Capability	Education	Week 1 – Step into Sexual Health	<p>1.1.1 Mutual acquaintance and trust: All participants introduce themselves through ice-breaking games to reduce initial unfamiliarity.</p> <p>1.1.2 Introduce the intervention's themes, process, and precautions to ensure students understand the detailed structure and expectations.</p> <p>1.1.3 Acquire sexual health knowledge: Teach and facilitate group discussions on sexual health concepts, the social construction of sexuality, and the relationship between sex and gender.</p> <p>1.2.1 Accept diverse sexual values and sexual minority groups: Explore sexual values and gender identity through movie clips.</p> <p>1.2.2 Knowledge quiz on correct condom selection and usage.</p> <p>1.2.3 Utilize the "Health Consideration" WeChat official account (featuring five sections: risk assessment, knowledge dissemination, interactive scenarios, and virtual services).</p> <p>2.1.1 Opening game: "Let's Hold Hands" to enhance familiarity and participation among students.</p> <p>2.1.2 Sexual knowledge quiz with point-based rewards.</p> <p>2.1.3 Teach the principles of attraction and methods to accurately understand attraction.</p> <p>2.2.1 Conduct group discussions analyzing personal attractiveness or relationship potential.</p> <p>2.2.2 Simulation exercises of attraction through skits.</p> <p>2.2.3 Assign a task: List and evaluate attraction relationships among classmates/friends.</p> <p>3.1.1 Opening game: "The Crow and the Pitcher," integrated with a love-themed mini-game.</p> <p>3.1.2 Teach recognition of sexual impulses and corresponding coping strategies.</p> <p>3.1.3 Approaches to establishing and maintaining intimate relationships: Use case analysis and reference the romance drama "The Story of the Rose" to explain the three elements of love and the concept of intimacy, including shared interests, respect, and communication.</p> <p>3.2.1 Interactive discussion on recognizing unhealthy or abnormal relationships.</p> <p>3.2.2 Reflect on past relationships through group discussions: "If I could start over..." to correct inappropriate behaviors.</p> <p>3.2.3 Practice communication and self-disclosure skills, sexual consent, refusal, and negotiation via the interactive game "Time Bomb."</p> <p>3.2.4 Assign a task: Practice communication and self-disclosure skills with close friends, documenting the process via video or written reflection.</p>	Group + Online push	90 min
Physical Capability	Training	Week 1 – Step into Sexual Health	<p>4.1.1 Opening game: Head-worn cardboard activity; participants share previous week's task completion, with points awarded.</p> <p>4.1.2 Strengthen risk awareness through metaphorical stories and classic educational warnings.</p> <p>4.2.1 Interactive demonstration of correct condom use with a rubber model.</p> <p>4.2.2 Practice condom use.</p> <p>4.2.3 Demonstrate STI prevention and safe sexual behaviors.</p> <p>4.2.4 Word-card scenario reenactments followed by group discussion; the researcher summarizes key points, including transmission routes, symptoms, detection, monitoring, prevention, and treatment of STIs.</p> <p>4.2.5 Assign a task: Maintain a reflection diary on risky sexual behaviors.</p>	Demonstration + Practice	90 min
Spontaneous Motivation	Training	Week 2 – Mutual Attraction	<p>5.1.1 Interactive game: Musical Bomb; participants share personal records and learning progress, with points awarded.</p> <p>5.1.2 Assess and recognize sexual risk factors using the "Health Consideration" WeChat official account; visual reports and number-based games guide participants to identify personal risk factors.</p> <p>5.1.3 Simulate recognition of risky situations, such as: casual sex through apps, drinking at bars, KTV encounters, or interactions with strangers.</p>	Group discussion	90 min
Reflective Motivation	Realization	Week 2 – Mutual Attraction		Role-play	90 min
Reflective Motivation	Persuasion and Training	Week 3 – Establishing Intimate Relationships		Interactive group activity	90 min
Reflective Motivation	Modeling	Week 3 – Establishing Intimate Relationships			
Reflective Motivation	Motivation	Week 4 – Safe Sexual Behaviors		Case discussion	90 min
Physical Opportunity	Education	Week 4 – Safe Sexual Behaviors		Skills training	90 min
Physical Opportunity	Restriction	Week 5 – Risk Recognition and Coping		Online + Group session	90 min

(continued on next page)

Table 3 (continued)

Primary Indicators (COM-B Component)	Second Indicators (Intervention Function)	Week & Theme	Tertiary Indicators (Key Intervention Contents)	Delivery Mode	Duration
Social Opportunity	Training	Week 5 – Risk Recognition and Coping	5.2.2 Practice interactive simulations of emergency situations. 5.2.3 Demonstrate acquisition and proper use of HIV test kits, including timely monitoring and treatment; provide STI knowledge and self-assessment tools. 5.2.4 Assign a task: Practice coping strategies using metaphorical games on the “Health Consideration” WeChat official account.	Simulation training	90 min
	Environmental Restructuring	Week 6 – Support and Maintenance	6.1.1 Opening game: Odd or Even, infused with sexual pleasure concepts; participants share task completion, with points awarded. 6.1.2 Discuss peer influences on risky sexual behaviors. 6.1.3 Teach proper use of social media and information evaluation skills. 6.2.1 Provide sexual health resources via the WeChat official account, including consultations, condom and test kit distribution, and educational content. 6.2.2 Sexual pleasure and rights: Group discussions on sexual and reproductive health rights and personal safety protection. 6.2.3 Offer interpersonal support and foster a mutual-assistance community. 6.2.4 Reaping Growth: Students share achievements, write messages to friends, celebrate a graduation ceremony, and receive certificates and gift packages.	Group discussion	90 min
	Enablement	Week 6 – Support and Maintenance		Group + Online support	90 min

Abbreviations: COM-B, Capability, Opportunity, Motivation-Behavior; KTV, Karaoke television entertainment venues; STI, Sexually Transmitted Infection; HIV, Human Immunodeficiency Virus.

4. Discussion

This study developed a comprehensive intervention program to reduce RSBs among Chinese college students by systematically applying the BCW framework and integrating empirical evidence, insights from the target population, and multidisciplinary expert consensus. The finalized COM-B–SRHP program demonstrates strong theoretical coherence, is grounded in empirical evidence, and exhibits robust content validity.

Persistently high rates of RSBs and their associated adverse health outcomes among college students underscore the ongoing need for innovative and effective interventions.⁴³ Many existing programs have demonstrated limited success in producing sustained behavioral change, partly because they fail to adequately address the underlying behavioral determinants identified by the COM-B model.⁴⁴ In this study, the COM-B framework served as a diagnostic lens in qualitative interviews to identify context-specific barriers and facilitators influencing students’ sexual behaviors. These empirically derived determinants directly informed the selection of BCW intervention functions (e.g., training to address skill deficits), ensuring that the final intervention represents a coherent, theory-driven program rather than a collection of disconnected activities.

Specifically, the program aims to enhance capability by interactive demonstration of condom use which may strengthening practical self-efficacy and coping skills through hands-on training, moving beyond the mere provision of abstract knowledge. To influence motivation, intervention activities help reshape outcome expectancies by reframing perceived costs and benefits of sexual decision-making, stimulate reflective motivation, and modify perceived social norms through peer modeling and guided reflection. Regarding opportunity, the program addresses both environmental and social constraints by increasing access to sexual health resources—thereby reducing physical and psychological barriers to safer sex—and by fostering supportive peer networks that reinforce positive behaviors. This multifaceted strategy is expected to bridge the widely recognized “knowledge–action gap” more effectively by transforming the conditions necessary for sustained safe sexual behavior. This structured mapping enhances the testability of the proposed mechanisms of change, allowing future studies to empirically examine whether changes in capability, opportunity, and motivation mediate behavioral outcomes.

The intervention was developed following rigorous methodological standards. An evidence-based design approach integrated findings from multiple data sources. Qualitative interviews provided rich, contextualized insights that grounded the abstract COM-B constructs in the lived experiences of college students, enhancing both cultural and developmental relevance. The Delphi method successfully synthesized expert perspectives from multiple disciplines. The high expert authority coefficient (Cr = 0.819) and the statistically significant increase in consensus (Kendall’s W = 0.437, *P* < 0.05) support the reliability of the consultation outcomes. Although Kendall’s W indicated moderate agreement, this level of consensus is generally considered acceptable for the early-stage development of complex, multi-component interventions. It may suggest that a need for modular flexibility or alternative delivery options for some certain sensitive components.

The COM-B–SRHP program was explicitly designed with practical implementation in mind. Its peer-led group format leverages social influence mechanisms and may reduce barriers to participation.⁴⁴ The six-week structure, with 90-minute sessions, balances intervention intensity with feasibility within a university academic schedule. The use of interactive and experiential learning strategies—such as games, scenario-based simulations, and metaphorical storytelling—aligns with evidence supporting skill acquisition in adolescent and young adult health education.¹³ In addition, integrating a digital component via a WeChat official account enables real-time access to resources and provides ongoing support beyond face-to-face sessions, potentially enhancing the sustainability of intervention effects. Clearly defined weekly themes and structured activities further increase the program’s adaptability and replicability across diverse university contexts. Collectively, these features provide a strong foundation for future feasibility testing and large-scale implementation.

Beyond its practical contribution, this study offers a detailed methodological example of operationalizing the BCW framework for a complex health behavior within a specific cultural and developmental context. It demonstrates how qualitative data can be systematically used to diagnose behavioral determinants and how these diagnoses can be translated into intervention functions and concrete activities. For universities and health professionals, the COM-B–SRHP program provides a ready-to-adapt, theory-based framework that prioritizes skill development and environmental support over didactic information delivery, aligning with contemporary principles of health promotion.

Several limitations of this study should be acknowledged. First, the qualitative sample was drawn from a single city in China and included limited representation of Lesbian, Gay, Bisexual, Transgender, and Queer (LGBTQ)+ students and individuals with specific trauma histories, which may restrict the generalizability of certain findings. Future research should purposively include these subgroups to enhance inclusivity and relevance. Second, although the literature search was completed in October 2023 and the core theoretical and empirical foundations remain robust, periodic updates are recommended to incorporate emerging evidence. Third, while the Delphi panel demonstrated strong expertise, specialists in sociology, law, and adolescent psychology were not included; their perspectives could further enrich future iterations of the program. Fourth, although statistically significant consensus was achieved, Kendall's W remained below the commonly cited threshold of 0.50 for strong agreement, indicating residual divergence among experts, particularly regarding sensitive intervention content. This highlights the importance of flexible implementation strategies and careful facilitation.

Most importantly, this study established the theoretical coherence and content validity of the COM-B–SRHP program. The next critical step is to evaluate its feasibility, acceptability, and preliminary effectiveness through pilot implementation studies. Future research should also examine the proposed mechanisms of change—such as improvements in self-efficacy and shifts in descriptive norms—to refine and optimize the program's active components.

5. Conclusion

Using a systematic mixed-methods approach guided by the Behavior Change Wheel framework, this study developed the COM-B–SRHP, a comprehensive intervention program aimed at reducing risky sexual behaviors among college students. The program is grounded in behavioral theory, empirical evidence, student perspectives, and expert consensus, making it both scientifically rigorous and practically relevant. It represents a promising advancement in theory-driven sexual health promotion within university settings. While the COM-B–SRHP provides a structured blueprint for implementation, further empirical evaluation is needed to establish its feasibility and effectiveness through pilot testing and outcome studies.

CRedit authorship contribution statement

Hui Zhang: Conceptualization, Study design, Writing – review & editing, Supervision, Funding acquisition, Project administration. **Qiusha Luo:** Methodology, Validation, Writing – review & editing, Supervision, Project administration. **Ying Li:** Writing – review & editing. **Tao Peng:** Conceptualization, Resources. **Jinwei Yang:** Conceptualization, Methodology, Validation, Supervision. **He Xu:** Resources, Formal analysis. **Xinya Xu:** Investigation, Resources, Data curation. **Rong Zhang:** Investigation, Formal analysis, Writing – original draft. All the authors have read and approved the final version of this manuscript.

Ethics approval

This study was approved by the Ethics Committee of Harbin Medical University, Daqing Campus (Approval No: HMUDQ20231116201). All

participants provided written informed consent. All methods were performed in accordance with the Declaration of Helsinki (2013) guidelines and regulations.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

The following are available online: Supplementary File contains: Table S1: Characteristics of Included Sexual Health Intervention Studies; Table S2: Cochrane's evaluation of RCTs; Table S3: JBI evaluation of quasi-experimental studies; Table S4: Semi-structured Interview Guide Mapped to the COM-B Framework; Table S5: APEASE-based Evaluation of Candidate Intervention Functions Table S6: The Draft Intervention Program.

Data Availability

The datasets generated and analyzed during the current study are not publicly available due to the sensitive nature of the interview data but are available from the corresponding author (Hui Zhang) on reasonable request and with appropriate ethical approvals.

Declaration of Competing Interest

No conflicts of interest.

Declaration of Generative AI and AI-assisted technologies in the writing process

DeepSeek-V3.2 was used solely for language polishing and formatting, and did not participate in data processing or the generation of conclusions. The content was reviewed throughout by the author, who assumes full responsibility for the entire work.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.hcr.2026.100065](https://doi.org/10.1016/j.hcr.2026.100065).

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