Effects of a creative crowdsourcing text-messaging intervention on sexual health outcomes among college students in Eastern China: A randomized controlled trial

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Ethics approval

Ethics approval was provided by the Research Ethics Committee of Xi'an Jiaotong – Liverpool University (XJTLU) (Registration number: S 19-02-75).

Informed consent

Online informed consent was obtained from all participants involved in the study.

Data availability

The datasets used and/or analyzed during the current investigation are accessible on reasonable request from the corresponding author.

Abstract

Background: Creative crowdsourcing may be an effective means to mitigate higher-risk sexual behaviors among college students in China. We conducted an 8-month Randomized Controlled Trial evaluating a crowdsourced health promotion and text-messaging intervention among first-year college students in Eastern China.

Methods: Participants were randomly assigned to four arms: Active Creative Crowdsourcing Engagement (ACCE) arm that created messages promoting sexual health (n = 129); Text-Messaging Intervention (TMI) arm that received health promotion messages bi-weekly (n = 111); ACCE-TMI arm that both created and received messages (n = 105); and the control arm (n = 135). Sexual health attitudes and behaviors in the past three months were analyzed at baseline and follow-ups.

Results: Among 480 participants at baseline, 57% identified as male, 8% were sexually active in the past three months and 4% had condomless sex. Proportion of sexually active participants increased in all arms between baseline and last follow-up. A total of 812 messages were submitted throughout the intervention period. Odds of condomless sex were 76% lower in the ACCE arm compared to the control arm (OR = 0.24; p = 0.02, 95% Confidence Interval [0.07, 0.79]). No difference in other sexual activity or attitudes towards condom use was observed between arms.

Conclusion: Study findings indicate that Active Creative Crowdsourcing is a feasible and potentially effective intervention for promoting safter sexual behaviors among college students in China. Future research should examine using Active Creative Crowdsourcing to promote healthier behaviors in other areas.

Keywords

sexually transmitted infections; HIV; condom use; young adults; mHealth; digital health; crowdsourcing; sexual health; text-messaging intervention; RCT; sexual health outcomes

Introduction

The passage between secondary school and university can be a crucial period for young adults (Habel et al., 2018; Pysmenna et al., 2020; Scholly et al., 2005). During this period, students undergo many changes to their lifestyle, as well as a developmental transition from adolescence to adulthood (Arnett, 2000; Liu et al., 2019).

In particular, the first year in university can be a period of sexual exploration and engagement in riskier sexual behaviors for young adults. College students might engage in higher-risk sexual behaviors such as condomless sex, which leads to a higher risk of contracting sexually transmitted infections (STIs) and unplanned pregnancies (Habel et al., 2018; Pysmenna et al., 2020; Scholly et al., 2005). Engagement in these riskier behaviors is influenced by the new social environment and perceived social norms students are placed in, in addition to a rise in romantic relationships and sexual exploration, including sexual debut, emerging sexuality, sexual orientation, and sexual identity (McNeely & Blanchard, 2010; Scull et al., 2020; Whiting et al., 2019). Young adults and college age adolescents account for almost half of all incident STIs, one-fifth of all prevalent infections, and about 10% of new HIV infections worldwide (Kreisel et al., 2021; Rowley et al., 2019; World Health Organization, 2018, n.d.).

However, young adults and college students in China face distinct challenges. Since China's Open Door Policy in the late 1970's and the economic reforms from the mid-1980s, there has not only been rapid economic development, but also increasing exchange between Western and Chinese cultures. These changes have led to a substantial shift in cultural values regarding sexual attitudes and behaviors (Chi et al., 2015; Choi et al., 2020; Jin et al., 2017; Xu et al., 2019; Zhan et al., 2021; Zhang & Beck, 1999; Xin ZHANG et al., 2017; Zheng et al., 2011). For example,

surveys found Chinese young adults being more open about sexual issues, increased engagement in premarital sex, and lower age of sexual debut (Chi et al., 2015; Xu et al., 2019; Zhang & Beck, 1999; L. Zhang et al., 2022; Zheng et al., 2011). Of great concern, there has been increased engagement in riskier sexual behaviors such as having multiple concurrent sexual partners and inconsistent condom use during sexual intercourse, with some studies reporting up to 53% of college students failing to use condoms during sexual intercourse (Choi et al., 2020; Du et al., 2021; Li et al., 2017; Ruan et al., 2019; Yu et al., 2013). Furthermore, studies have shown the incidence and prevalence of STIs increasing between 1990 and 2019, including for Chinese young adults aged 10-24 years (J. Zhang et al., 2022; L. Zhang et al., 2022; Zheng et al., 2022). In 2012, young people accounted for 12.6% of all HIV cases with 90% being acquired through sexual contact (Xu et al., 2019; Xiayan Zhang et al., 2017). In particular, there has been a reported annual growth rate of 30-50% of newly diagnosed HIV cases among college students in China in the past several years (Li et al., 2019).

Researchers have identified lack of awareness and sexual knowledge as major factors in the transmission of STIs and HIV (Choi et al., 2020; Jin et al., 2017; Xu et al., 2019; Zhan et al., 2021; Xin ZHANG et al., 2017). Particularly in China, sexual education and knowledge among young adults has been limited (Choi et al., 2020; Jin et al., 2017; Xu et al., 2019; Zhan et al., 2021; Xin ZHANG et al., 2017). Therefore, it is of major public health interest to promote sexual and reproductive health knowledge among first year Chinese college students to improve individual understanding and confidence in making healthier sexual decisions (e.g., condom use) (Choi et al., 2020; Jin et al., 2017; Xu et al., 2019; Zhan et al., 2021; Xin ZHANG et al., 2017).

Theoretical framework & interventions

Health belief model

The Health Belief Model (HBM) is a cognitive-based theory that views health behavior change based on the perceptions and balance between the barriers to and benefits of an action (Green et al., 2020; Rosenstock, 1974a, 1974b; Rosenstock et al., 1988). The HBM utilizes six constructs including: *Perceived susceptibility* (perceived risk of contracting or developing a health condition or illness; *perceived severity* (perceived seriousness of a condition or illness and its potential consequences); *perceived benefits* (efficacy from engaging in a health behavior in reducing or preventing a health condition); *perceived barriers* (obstacles to undertaking a health behavior); *cues to action* (internal or external cues that prompts an individual to perform a behavior); and *self-efficacy* (conviction of successfully executing the behavior) (Green et al., 2020; Haller et al., 2008; Reid & Aiken, 2011; Rosenstock, 1974a). Particularly, the HBM has been successfully used to predict health behaviors (Anuar et al., 2020; Green et al., 2020; Munro et al., 2007). Studies using the HBM have found that when the perceived benefits and perceived threat (susceptibility) outweigh perceived barriers, individuals are more likely to engage in a health behavior (Anuar et al., 2020; Carpenter, 2010; Green et al., 2020; Munro et al., 2007). In other words, HBM predicts that an individual's perceptions of disease severity and personal susceptibility to the disease influences a specific health behavior (Etheridge et al., 2023; Rosenstock, 1974a).

In sexual health promotion, the HBM constructs of perceived benefits and perceived barriers have been found to be strong predictors of health behaviors such as male and female condom use, HIV and STI testing, and uptake of HIV prevention and management among diverse populations (Hall, 2012; Hiltabiddle, 1996; Reid & Aiken, 2011; Rosenstock et al., 1994; Sheeran & Taylor, 1999; Sulat et al., 2018; Tarkang et al., 2023; Tarkang & Zotor, 2015;

Whiting et al., 2019; Zhao et al., 2012). Perceived susceptibility and cues to action have also been found to predict these behaviors, although to a lesser extent (Reid & Aiken, 2011; Sheeran & Taylor, 1999; Sulat et al., 2018; Tarkang et al., 2023).

Transtheoretical model

The Transtheoretical Model (TTM), also known as stages of change model, is a framework that explains the progress of an individual's behavior change through five stages of change: precontemplation, contemplation, preparation, action, and maintenance (Grimley et al., 1997; Prochaska & Velicer, 1997; Prochaska et al., 1994). To promote behavior change, the TTM uses constructs and processes to guide and assist individuals' progress between stages; for example, some constructs affecting progress from the precontemplation to the preparation stages include *consciousness raising* (increasing awareness of the issue), *self-reevaluation* (assessing their behavior), *self-liberation* (choosing and committing to behavior change), and *stimulus control* (adding cues to trigger new behavior). Other constructs affecting progress at all stages include *attitudes*, *self-efficacy* (conviction of successfully executing the behavior), and *decisional balance* (weighing up advantages and disadvantages) (Grimley et al., 1997; Prochaska & Velicer, 1997; Prochaska et al., 1994). In sexual health promotion, researchers have asserted that the first step to adopting a behavior is awareness and knowledge of the issue (*consciousness raising*) and that promoting sexual and reproductive health knowledge improves an individual's ability and confidence in making healthier sexual decisions (Chi et al., 2015; Grimley et al., 1997; Karatana et al., 2022; Prochaska & Velicer, 1997; Prochaska et al., 1994; Tung et al., 2012; Tung et al., 2013; Zhang et al., 2010).

Text-messaging interventions

Mobile phone technology for health (mHealth) consists of using mobile phones and/or other communication technologies in various capacities to increase health knowledge, promote health behaviors, collect health data, and deliver test results (Hall et al., 2015; Whittaker et al., 2012). Text-messaging interventions (TMIs) make use of mobile phone technology or internet sites, (e.g., text-messaging or short messaging services – SMS – and multimedia message services – MMS) and have been utilized in public health as a health promotion intervention. TMIs have been found to be cost-effective, convenient, scalable and efficient interventions for health promotion and behavior change that keep participants engaged (Abroms et al., 2012; Abroms et al., 2015; Gold et al., 2011; Hall et al., 2015; Head et al., 2013; Whittaker et al., 2012). Research has found TMIs to be effective in improving multiple health outcomes and targeting behavior change (Abroms et al., 2012; Abroms et al., 2015; Head et al., 2013; Whittaker et al., 2012). In regard to sexual health promotion, studies have utilized TMIs to promote knowledge and awareness, address attitudes, improve uptake of condoms and contraception methods use, and increase STI and HIV testing to varying degrees of success (Berendes et al., 2021; Feroz et al., 2021; Gilbey et al., 2020; Gold et al., 2011; Lim et al., 2008; Rokicki et al., 2017; Widman et al., 2020).

TMIs also provide an opportunity to develop and implement effective health promotion and communication interventions by tailoring and personalizing text-messages to the target individuals' characteristics and perceived barriers, especially when participants cooperate and engage in the development of the text-messages (Abroms et al., 2012; Abroms et al., 2015; Gilbey et al., 2020; Guerrero et al., 2020; Head et al., 2013).

Active creative crowdsourcing intervention

Crowdsourcing is defined as obtaining services, ideas, and content voluntarily from a group of people (Estellés-Arolas & González-Ladrón-de-Guevara, 2012; Merriam-Webster, n.d.; Naslund et al., 2015; Ranard et al., 2014). Researchers have categorized crowdsourcing based on the activities performed, type of participants involved, and levels of participation. For example, Brabham et al. (2014) describes four types of crowdsourcing based on participation levels: Knowledge Discovery and Management (tasking crowds with finding and collecting information); Distributed Human Intelligence Tasking (tasks crowds with analyzing large amounts of information); Broadcast Search (tasks crowds with solving empirical problems); and Peer-Vetted Creative Production (tasks crowds with creating and selecting creative ideas), the latter being the most participative and active by involving significant engagement from a crowd in creating and selecting ideas.

In public health, crowdsourcing is an approach to conducting interventions that has provided innovative solutions to health issues and positive effects in improving the implementation of public health interventions (Brabham et al., 2014; Créquit et al., 2018; Marks et al., 2022; Pan et al., 2017; Ranard et al., 2014; Stowell et al., 2020; Tucker et al., 2019; Tucker et al., 2018). Crowdsourcing methods and activities have been utilized in the promotion and prevention of various health issues (Naslund et al., 2015; W. Tang et al., 2019; Tucker et al., 2018; Wu et al., 2019). Engagement in creative crowdsourcing activities has been shown to enhance public health interventions by working with communities, engaging active user participation, and strengthening relations and sustainability (Brabham et al., 2014; Ranard et al., 2014; Wallerstein & Duran, 2010; Wang et al., 2020). Furthermore, engagement in crowdsourcing activities has been associated with improving health outcomes such as increasing knowledge and raising awareness about diverse health concerns and improving health behaviors (Wazny, 2017:

Thawrani et al., 2014). Particularly, the use of crowdsourcing activities in sexual health interventions has been documented; for example, crowdsourcing interventions have shown evidence of positive effects in STI testing, HIV testing, condom use, understanding perceptions and attitudes towards STI, addressing stigma towards STI, and for promoting HIV research (Fitzpatrick et al., 2018; Kpokiri et al., 2023; Mathews et al., 2017; Shen et al., 2020; Srinivas et al., 2021; W. Tang et al., 2019; W. M. Tang et al., 2019; Wu et al., 2019).

Current Intervention & justification

Based on the Peer-Vetted Creative Production approach for crowdsourcing activities by Brabham et al., (2014), we propose Active Creative Crowdsourcing Engagement (ACCE) as a health behavior intervention. We defined ACCE as the process of active creation and contribution by individuals in response to an open crowdsourcing call for ideas and/or products. Following the constructs of the Health Belief Model, the Transtheoretical Model, and previous literature, we developed an intervention using both ACCE and text-messaging (ACCE-TMI) as means to increase the awareness and knowledge of sexual health issues among Chinese first year university students. The ACCE-TMI intervention's activities target the constructs of self-efficacy, perceived susceptibility, and perceived benefits by means of external cues to action (Figure 1). We hypothesized that the ACCE-TMI intervention would reduce frequency of condomless sex.

Furthermore, while the benefits of crowdsourcing activities have been studied and documented in systematic reviews of crowdsourcing interventions (Marks et al., 2022; Pan et al., 2017; W. Tang et al., 2019); research on the effects of ACCE on participants remains limited. Previous research on the actors and participants of crowdsourcing activities has been restricted to the

acceptability of the intervention, satisfaction with the material or activities, or feasibility of the intervention development and implementation (Li et al., 2020; Mathews et al., 2017; Wong et al., 2018; Wu et al., 2019; Yan et al., 2022; Zhang et al., 2019).

The aim of this research study was to evaluate the effects of ACCE and TMI on sexual health outcomes among first year college students in Suzhou, China. Specifically, the study analyzed and compared the effects of creating health promotion messages (ACCE), receiving health promotion messages via text-messaging (TMI), and engagement in both activities (ACCE-TMI).

Methods and materials

Study design

We conducted a parallel 4-arm design Randomized Controlled Trial (RCT) to assess the efficacy of a health promotion intervention using ACCE and Health Promotion TMI approaches. Participants were randomly allocated to four arms with different activities assigned at a 1:1:1:1 ratio: (1) ACCE (n = 129), (2) TMI (n = 111), (3) ACCE-TMI (n = 105), and (4) control (n = 135). The intervention lasted 8 months with follow-up surveys at 4 months and 8 months. An additional post-intervention follow-up survey was completed at 12 months (four months after completion of the intervention). The study was registered in the Chinese Clinical Trial Registry (https://www.chictr.org.cn) on September 22nd, 2020 (Registration Number: ChiCTR2000038402) and was approved by the Research Ethics Committee of Xi'an Jiaotong – Liverpool University (XJTLU) (Registration number: S 19-02-75).

Participant recruitment and inclusion criteria

A total of 480 participants were included in the study sample. Inclusion criteria consisted of (1) being 18 years or older, (2) a first-year university student (3) living in Suzhou, China, and (4) willing to provide a mobile phone number for contact at follow-ups. Participant recruitment was done via email invitations shared to undergraduate students at a transnational university. Poster flyers were also distributed at colleges and universities in the study city, as well as popular Chinese social media platforms such as *Weibo/WeChat.* Text-messages with a thank you message inviting participants to share the baseline questionnaire with peers were also sent after completing the survey. The message encouraged participants to share the questionnaire and link with other fellow students to promote a snowball effect.

Consent to participate in the study was obtained prior to completing the baseline survey and providing a phone number. An information page with a description of the study, consent information, and a consent statement was provided at the beginning of the questionnaire before any collection of participant data. Upon consenting, participants were screened for eligibility. Participants were compensated with phone credits after completing the baseline survey and each follow-up survey regardless of arm assignment.

Interventions

Upon completing the baseline survey, participants were assigned to one of four arms corresponding to one of the interventions or the control arm. Individuals allocated to Arm (1) were assigned to the ACCE intervention. Following the HBM and TTM constructs of cues to action, consciousness raising, and self-reevaluation, participants in this arm were invited to develop and submit health promotion messages and images at the end of the questionnaire on the same platform as the survey. Participants were prompted to submit messages that would

encourage safer sexual practices to fellow study participants. Participants were given the option to submit written messages, images, or both without any time limits (Appendix A). Post-submission, health promotion messages were evaluated and ranked by two independent reviewers, one being an expert in communication and sexual health promotion (B.C.), and the other a college health counselor. Participants in the ACCE arm were asked to repeat the task at the four- and eight-month follow-ups after completing the questionnaires. This timing was selected to coincide with the follow-ups for practicality in contacting participants as well as to obtain new crowdsourced health promotion messages for distribution to participants in Arm (2) (TMI).

Participants allocated to Arm (2) acted solely as recipients of the TMI health promotion messages created by participants allocated to the ACCE arm. Participants from Arm (2) were not invited to develop health promotion messages but received health promotion messages every two weeks for the eight months of the intervention. A bi-weekly schedule was selected to allow enough time for preparation and distribution as text-messages were sent by the research staff. The activities for this intervention (i.e., receiving health promotion messages via text-message) draw from the HBM constructs of cues to action, self-efficacy, perceived susceptibility, and perceived benefits, and well as the TTM constructs of consciousness raising, self-reevaluation, and stimulus control depending on the contents of the health promotion messages.

Individuals allocated to Arm (3), were assigned to participate in the ACCE activities (health promotion messages development) and were also recipients of the health promotion text messages (TMI). In other words, individuals in Arm (3) were participants in both interventions, which we refer to as the ACCE-TMI intervention. Similar to participants in Arm (1) (ACCE intervention), participants in the ACCE-TMI arm were asked to repeat the health promotion

message creation task at the four- and eight-month follow-ups after completing the questionnaires.

Participants assigned to Arm (4) (control arm) were asked to complete the survey questionnaires at baseline and follow-ups, but no additional activity (e.g., message creation or text message receipt) was required from the participants in the control arm.

Outcomes and measurement tools

Data collection was conducted at four times: baseline, 4-months, 8-months, and 12 months (four months post-intervention). For each data collection period, participants were contacted via text-message (by phone number provided at baseline) with an invitation and a link to complete the survey. Data was collected via an online questionnaire using Qualtrics software (Provo, UT) at baseline and SurveyMonkey (San Mateo, CA) at follow-ups. Translation of scales and questionnaires to Mandarin Chinese was performed by native speakers in the case of a Chinese translation not being publicly available or made available after request to authors. Translation was validated by back translation by another member of the research team not involved in the original translation. Additionally, adaptation and tailoring to a Chinese setting was done by native Mandarin speaking research staff for questions as needed.

Active creative crowdsourcing engagement

Data collected on ACCE activity included the number of participants contributing to the ACCE activity and number of health promotion messages developed. ACCE activity was collected at baseline and at the 4- and 8-month follow-ups through online surveys. ACCE activity was measured by three items: (1) number of participants that participated in ACCE activities by providing health promotion messages or images, (2) number of messages and images submitted

by individual and overall sample, and (3) quality of the health promotion messages or images as scored by the two independent reviewers.

Sexual health outcomes

The sexual health outcomes of interest included sexual activity, condom use, testing for STIs, and attitudes and beliefs towards condom use behaviors. We adapted questions from the National Survey of Adolescents and Young Adults – Sexual Health Knowledge, Attitudes and Experiences by the Kaiser Family Foundation (Hoff et al., 2003). Twenty adapted questions from the Sexual Health Knowledge, Attitudes and Experiences scale were utilized, of which five evaluated attitudes toward condom use through a 7-point Likert scale ranging from very much disagree to very much agree (Appendix B).

Sample Size

Assuming a 10% incidence in intervention arms[1-3] and 20% in the control[4] arm of experiencing an adverse health outcome, a sample size of 199 participants in each arm would have yielded 80% power to detect a statistically significant difference at $\alpha = 0.05$. The statistical power to detect such a difference dropped to 58% when the sample size in each arm declined to 120 participants.

Randomization

In this parallel 4-arm RCT, participants were allocated to one of four arms in a 1:1:1:1 ratio: ACCE[1] intervention creating health promoting messages, TMI[2] receiving health promotion messages via text, ACCE-TMI[3] intervention creating and receiving health promotion messages , and control[4] arm. Randomization was done through the randomizer feature in the Qualtrics

software (Provo, UT). Qualtrics' randomizer feature allocated participants to one of the four arms after completing the baseline survey and before requesting participation in any of the intervention activities.

Data Analysis

Data analysis was performed using Stata Corp. 2021 (*Stata Statistical Software: Release 17*. College Station, TX: StataCorp LLC). Substantial attrition rates were observed at follow-ups. To account for missing data, we implemented a complete case analysis where only cases that completed the baseline survey and at least one of the three follow-up surveys were included in the statistical analysis. Participants that only completed the baseline survey and 12-month follow-up (four months after completion of the intervention) were also included in the analysis as they would have been exposed to the ACCE intervention at baseline (ACCE[1] and ACCE-TMI[3] arms). Similarly, participants in the TMI[2] arm would have received text-messaging health promotion messages on a bi-weekly basis. Multiple Imputation and other types of methods for handling missing data were considered, but given the high attrition rate, the sample did not meet assumptions appropriate for their utilization.

Paired t-test and Wilcoxon Rank tests were conducted to assess statistical differences between baseline and last follow-up within each intervention arm. Chi-square tests and Generalized Estimating Equations (GEE) analysis with multivariable repeated measures regression was conducted to assess statistical differences between intervention arms. A post-hoc multivariable regression analysis for intervention impacts on any sexual activity in the past three months stratified by sex at birth and sexual minority status at baseline was also performed (Appendix D).

Results

Eligibility & participation

A total of 1,321 individuals initiated the baseline survey and 1,015 completed the survey. Of the 1,015 participants, 144 individuals were excluded after screening for eligibility (111 were not freshmen/Year 1 students or were not studying in China, and 33 individuals were younger than 18 years old at baseline). The remaining 871 individuals were randomly allocated into four arms by the Qualtrics software (Provo, UT). Sixty-four participants were removed post randomization and allocation due to duplicate phone number entries: nine from the ACCE[1] arm, 16 from TMI[2] arm, 29 from ACCE-TMI[3] arm, and 10 from control arm[4]. Upon removal of duplicate participants based on phone number provided, the final count of allocated participants was 807. However, we observed significant attrition rates at follow-ups among all arms, with only 38% (n = 307) completing the questionnaires at the 4-month follow-up, 45% (n = 362) at the 8-month follow-up, and 43% (n = 350) at the 12-month follow-up. Therefore, for this study, we implemented a complete case analysis where participants that completed at least one follow-up were included in the current analysis. This led to a final analytic study sample of 480 participants (Fig. 1).

Attrition Analysis

Of the 807 participants who enrolled at baseline, there was an attrition rate of 41% (n = 327). To assess predictors of participant drop out, we ran a multivariable logistic regression model of multiple sociodemographic and behavioral covariates regressed on drop out (yes/no). Results indicated that individuals allocated to the TMI[2] arm were significantly more likely to drop out of the study. Additional results of the attrition analysis are presented in Appendix C.

Demographic characteristics

Table 1 presents participants' baseline sociodemographic and sexual behavior characteristics. Of the 480 participants included in the analytic sample, 300 (63%) reported being 18 years old, 247 (51%) identified as male, 402 (84%) reported being heterosexual, and 381 (79%) reported being single or not in a romantic relationship.

Seventy (15%) out of the 480 participants reported ever having vaginal, anal, or oral sex in the past. Of these 70, 58 (83%) reported first being sexually active at the age of 18 or younger and 48 (68%) only having one prior sexual partner.

At baseline, among the 480 participants of the analytic sample, 39 (8%) participants reported having sexual activity in the previous three months, 17 (4%) participants reported having condomless sex in the past three months, and 53 (11%) participants reported testing for STIs in the past three months. Baseline prevalence of "any sexual activity", condomless sex, and STI testing were not significantly different between study arms (Table 2).

Attitudes towards condom use

At baseline, among the 480 study participants, 327 (68%) participants reported feeling confident using condom during sex, 449 (94%) reported not having difficulty obtaining a condom, 434 (90%) agreed that it is not safe to occasionally have sex without condoms, and 396 (83%) agreed that condoms are an efficient way to avoid STIs and unwanted pregnancies. At baseline, there was no statistically significant difference between arms regarding attitudes towards condom use (Table 3). In the bivariable GEE analysis, no significant associations were detected between intervention arm and condom use attitudes.

Intervention outcomes

Active creative crowdsourcing engagement

At baseline, 398 sexual health promotion messages were received, including 349 in text format and 49 as images. At the 4-month follow-up, 185 messages were received (159 in text format and 26 as images), and 229 messages at the 8-month follow-up (209 in text format and 20 in images).

Among the eligible participants in the ACCE[1] (n = 204) and ACCE-TMI[3] (n = 187) arms at baseline, 372 (95%) made one submission and 19 (5%) more than one. At the 4 and 8-month follow-ups, 116 (79%) and 216 (78%) participants made at least one submission, respectively.

Sexual health behaviors in the past three months

The bivariable GEE analysis showed that odds of condomless sex in the past three months were 76% lower in the ACCE[1] arm compared to the control[4] arm (OR = 0.24; p = 0.02, CI 95% [0.07, 0.79]) (Table 4).

After adjusting for time of the follow-up, age, sex at birth, sexual orientation, having a sexual partner, past sexual activity, remote learning, PHQ-4 levels, prosocial behavior (ever donated blood), and collectivism level in the multivariable GEE analysis, the odds of condomless sex in the past three months were 84% lower in the ACCE[1] arm compared to the control[4] arm (OR = 0.16; p = 0.01, CI 95% [0.04, 0.65]). No significant differences were observed in rates of condomless sex for either the TMI[2] or ACCE-TMI[3] arms compared to the control arm (Table 6).

The bivariable GEE analysis showed that the odds of STI testing during the past three months were 88% lower in the ACCE[1] arm versus the control[4] arm (OR = 0.12; p = 0.01, CI 95% [0.02, 0.57]) and 76% lower in the TMI[2] arm compared to the control[4] arm (OR = 0.24; p = 0.04, CI

95% [0.06, 0.93]) (Table 4) (Note: Potential reasons for these observed lower rates of STI testing in these intervention arms are given in the Discussion).

After adjusting for time of the follow-up, age, sex at birth, sexual orientation, having a sexual partner, past sexual activity, remote learning, PHQ-4 levels, prosocial behavior (ever donated blood), and collectivism level in the multivariable GEE analysis, the relative odds of not testing for STIs increased from 88% to 90% in the ACCE[1] arm compared to the control[4] arm (*OR* = 0.10; $p = 0.01$, CI 95% [0.02, 0.57]), while the relative odds diminished for the TMI[2] arm, becoming non-significantly different from the control[4] arm (*OR* = 0.33; $p = 0.16$, CI 95% [0.07, 1.53]) (Table 7). No statistically significant difference in rate of STI testing was observed between the ACCE-TMI[3] arm versus the control[4] arm.

Discussion

In this study, we implemented three interventions, an (1) ACCE intervention, a (2) TMI and a combined (3) ACCE-TMI intervention aimed to decrease condomless sex and increase STI testing based on the Health Belief Model (HBM) and the Transtheoretical Model (TTM). The purpose of our study was to evaluate and compare the effects of ACCE[1] and TMI[2] interventions on sexual health outcomes. We hypothesized that participating and engaging in creative crowdsourcing and receiving health promotion messages via text-messages would lead to positive changes in health behaviors by targeting the HBM constructs of *perceived susceptibility*, *perceived severity*, *perceived benefits*, *perceived barriers*, and *cues to action;* as well as the processes from the TTM of *consciousness raising, self-reevaluation, self-liberation*, *stimulus control*, and *decisional balance* (Brabham et al., 2014; Thawrani et al., 2014; Wazny, 2017).

Results of the study show evidence of Active Creative Crowdsourcing decreasing odds of condomless sex and STI testing by 84% and 90% respectively compared to the control[4] arm. The lower likelihood of STI testing among the ACCE[1] arm may be because ACCE[1] arm participants were less likely to have condomless sex and therefore may have felt at lower risk of STI exposure.

However, the TMI[2] and ACCE-TMI[3] interventions were not found to be associated with any sexual health outcomes in the multivariable GEE analysis. In addition, no statistically significant differences between arms in attitudes towards condom use were observed among study participants.

There are several possible explanations for the null findings for the TMI[2] and ACCE-TMI[3] arms. First, Grimley et al., (1997) explain that for individuals at early stages of the TTM, the disadvantages or barriers to adopting a health behavior usually outweigh the advantages. To move to later stages of the TTM, a shift between pros and cons should occur, which can be accomplished by promoting the advantages of healthier sexual behaviors while addressing or minimizing barriers and disadvantages of the behavior (i.e., decisional balance). This phenomenon was also seen in studies where participants experienced a shift or increase in the perceived advantages of engaging in healthy sexual behaviors (Karatana et al., 2022; Tung et al., 2012; Tung et al., 2013). In our study, participants were asked to create health promotion messages for fellow college students. While these messages were reviewed and ranked by disciplinary experts, it is possible that message recipients may not have received any new knowledge, in which case the process of decisional balance may not have been directly addressed. While some participants may have received new information from the messages or

reflected on the benefits of engaging in healthier behaviors while participating in the activity, this internal debate was not explicitly addressed.

Second, there was a lack of individual tailoring and dosing the health promotion message interventions. Studies have shown that message tailoring and personalization are associated with greater intervention efficacy (Head et al., 2013; Lueck, 2018; Siegel et al., 2017). Additionally, current literature on internet-based and text-messaging interventions are still researching questions such as the appropriate dose of text messages (e.g., time and frequency), the appropriate content for text messages (e.g., framing of messages, how to minimize health literacy demands), and the inclusion of other media (photos, video, social media, etc.) (Abroms et al., 2012). Thus, as intimated by Lueck (2018) and Siegel et al. (2017), the TMI^2 intervention may have been more effective if it provided activities that targeted specific populations or health behaviors by implementing more specific prompts (e.g., sharing previous experiences) or having different types of creative crowdsourcing activities.

Strengths, limitations, & recommendations

To the best of our knowledge, this is the first study in China to evaluate the effects of both a creative crowdsourcing and text-messaging intervention on individual sexual health outcomes. The results of this study show evidence of ACCE being a potentially effective tool in reducing condomless sex. Moreover, this study provides an innovative approach to crowdsourcing methodologies by documenting its use as an intervention. Though this study targeted college students in China due to the upsurge of STI and HIV infections in this population, intervention approaches used in this study may be applicable to youth and young adults in China more generally (Li et al., 2019). Therefore, this study contributes to the growing literature on the use

and effectiveness of crowdsourcing methods and mHealth technologies for public health interventions. Most important, it provides evidence of the feasibility of crowdsourced interventions in a broader Chinese setting.

Furthermore, we observed high rates of engagement and participation in ACCE activities (e.g., development of messages) among participants that completed the follow-up surveys. We observed a mean of 96% participation in the ACCE activities by participants in the ACCE[1] and ACCE-TMI[3] arms that completed the follow-up questionnaire.

Nevertheless, the study was not without limitations. One major limitation was the attrition rate. Of the 807 eligible participants enrolled into the study at baseline, there was an attrition rate of 62% at Follow-up 1, 55% at Follow-up 2, and 57% at Follow-up 3. Nonetheless, ACCE was still found to be significantly associated with condom use, despite the modest sample size.

The study began enrollment in December 2020 and concluded in February 2021. While there were no lockdown restrictions due to COVID-19 in China at the time of enrollment, over the course of the subsequent months, China experienced multiple lockdowns and consequently universities experienced periods of change between online and in-person learning. One potential effect from the lockdowns due to the COVID-19 pandemic and social distancing practices is a decrease in sexual activity among participants due to potentially fewer opportunities for social encounters, population movement, and/or extra precaution against in-person contact. Practical barriers to seeking health services for sexual health (e.g., STI testing) could have also been exacerbated by limited access and/or disruptions of these services due to the COVID-19 pandemic.

While these challenges do not undermine validity of the results, it is important to point out these challenges for future study replication and implementation. Therefore, given the limitations encountered in this study, a follow-up study is being planned. This follow-up study will focus on a broader age group of young adults, and will include needs assessments, more robust behavior change models, and implementation of the lessons learned from this study.

We recommend future research and public health interventions planning to use ACCE and TMI to consider providing information to target decisional balance and resources for health seeking behaviors more explicitly, as Grimley et al., (1997) explained. Similarly, health promotion messages and crowdsourcing activities should be tailored to the intended population as explained by Lueck (2018) and Siegel et al. (2017) by either piloting the activities and messages with the target population or working in collaboration with stakeholders.

Lastly, being the first study in China to evaluate a creative crowdsourcing and a text- messaging intervention individually and combined, this study contributes to their feasibility in China. While this study had mixed results on the effects of the interventions on sexual health outcomes, the study shows ACCE being a potentially effective intervention in reducing condomless sex. Furthermore, the high engagement in ACCE activities by participants indicates the possibility of implementing similar interventions and methodologies in a Chinese setting and provides an opportunity to explore the effects of creative crowdsourcing on other health behaviors or outcomes (e.g., HIV testing, mental health, smoking cessation).

Conclusion

Active Creative Crowdsourcing methodologies and activities may be an effective intervention in addressing riskier sexual health behaviors among college students and young adults in China.

The utilization of crowdsourcing methods and mHealth technologies in public health interventions is a growing field that allows for engagement of stake holders and empowers participants by co-creation, collaboration, and ownership which contributes to equity in public health. This study not only contributes to the feasibility but also the literature, research, and implementation of these public health interventions for college students and young adults in a Chinese setting.

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