An Internet Quiz Game Intervention for Adolescent Alcohol Drinking: A Clustered RCT

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abstract

BACKGROUND AND OBJECTIVES: Interventions on adolescent drinking have yielded mixed results. We assessed the effectiveness of an Internet quiz game intervention compared to conventional health education.

METHODS: In this cluster randomized controlled trial with parallel group design, we randomly allocated 30 participating schools to the Internet quiz game intervention or the conventional health education (comparison) group, with 1:1 ratio. Students of Hong Kong secondary schools (aged 12–15 years) were recruited. The intervention was a 4-week Web-based quiz game competition in which participating students answered 1000 alcohol-related multiple-choice quiz questions. The comparison group received a printed promotional leaflet and hyperlinks to alcohol-related information.

RESULTS: Of 30 eligible schools, 15 (4294 students) were randomly assigned to the Internet quiz game intervention group and 15 (3498 students) to the comparison group. Average age of participants was 13.30 years. No significant between-group differences were identified at baseline. Overall retention rate for students was 86.0%. At 1-month follow-up, fewer students in the intervention group reported drinking (9.8% vs 12.1%, risk ratio 0.79, 95% confidence interval [CI] 0.68 to 0.92; $P = .003$), and those who drank reported drinking less alcohol (standardized difference β −0.06, 95% CI −0.11 to −0.01; $P = .02$). Between-group differences remained statistically significant at 3-month follow-up (10.4% vs 11.6%, risk ratio 0.86, 95% CI 0.74 to 0.999; $P = .048$; β −0.06, 95% CI −0.11 to −0.01; $P = .02$).

CONCLUSIONS: The Internet quiz game intervention reduced underage drinking by 21% at 1-month and 14% at 3-month follow-up compared with conventional health education.

WHAT'S KNOWN ON THIS SUBJECT: Underage drinking is an important public health problem, but previous interventions on adolescents have yielded mixed results.

WHAT THIS STUDY ADDS: With the Internet quiz game intervention, underage drinking was reduced by 21% at 1-month and 14% at 3-month follow-up compared with conventional health education. Interactive online game–based intervention may be a viable alternative to conventional health education for adolescents.

Drinking under legal age is an important global public health problem. A wide range of health and behavioral problems have been associated with underage drinking, such as traffic accidents, sleep problems, mental health issues, and substance abuse.[1,2] These outcomes not only increase mortality and decrease quality of life but also pose substantial costs to society.[3] Underage drinking can lead to excessive alcohol consumption in adulthood.[4,5] Therefore, early interventions are recommended for adolescents.[6]

Underage drinking is prevalent globally.[7] In 2018, 9.0% of American individuals aged <18 years drank alcohol, and among them, 4.7% reported binge drinking.[8] In Hong Kong, the most Westernized city in China, a 2018 survey revealed that 21.2% of secondary school students consumed alcohol in the past 30 days.[9] More importantly, since 2008, Hong Kong has adopted a zero wine and beer tax policy, which has been found to be associated with increasing drinking prevalence.[10] From 2006 to 2007 to 2017 to 2018, the prevalence of alcohol consumption in the past 30 days has risen from 19.1% to 21.0% and from 16.5% to 21.3% among adolescent boys and girls, respectively.[11] There is a pressing need to intervene on the growing trend of underage drinking in Hong Kong.

Adolescence is a stressful developmental stage, during which feelings of insecurity and sensation seeking are high.[12] Conventional interventions, which act through unidirectional knowledge transfer, such as health education seminars and leaflets, have not been proven effective to change risk behaviors among youth.[13] Adolescents are more adept with and open to Internet communications.[14] Indeed, previous reviews found Internet

interventions to have significant, albeit heterogenous, effects.[15] In Hong Kong, our team conducted a quasi-experimental (pretest and posttest only) study of an Internet quiz game intervention that improved antismoking attitudes in Chinese adolescents and that showed both school teachers and students were in favor of such an intervention model.[16] The present trial was the first to implement an Internet quiz game intervention to reduce underage drinking in secondary schools[17] and compare it with conventional health education intervention. In this study, we hypothesize that delivery medium of health information could affect the likelihood of behavioral change. Specifically, the Internet quiz game intervention would be more effective in reducing underage drinking than would conventional health education intervention.

METHODS

Study Design and Participants

This cluster randomized controlled trial (RCT) with parallel group design was conducted from September 2016 to April 2017 in Hong Kong. Secondary schools were the unit of randomization, with 1:1 allocation ratio. All local (noninternational) schools were eligible. Schools targeting students with special needs (eg, intellectual disabilities) were excluded. All secondary 1–3 grade (equivalent to US grades 7–9) students of the participating schools were invited to participate. Such classes were selected because these students were at high risk of initiating alcohol use. Students who could not comprehend basic written Chinese (<0.1%) were excluded because the questionnaires and interventions were done in Chinese. Full trial protocol is available elsewhere[18] and was registered in www.ClinicalTrials.gov (NCT02450344).

The study was approved by the ethical committee Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. All participants and their parents' written consents were obtained before study commencement.

Implementation

Forty secondary schools randomly selected from the 4 major regions (Hong Kong Island, Kowloon, and East and West New Territories) of Hong Kong were assessed for eligibility in this trial. Among them, 30 were eligible. These schools were located in different areas of Hong Kong with diverse socioeconomic backgrounds.

Schools were allocated by using a random sequence, centrally generated by using R statistical software (version 3.2.1), to either the Internet quiz game intervention group or the conventional health education (comparison) group. Randomization of schools were completed simultaneously to avoid allocation concealment bias.

An invitation was sent to each selected school. After the school principal agreed to join this trial, informed written consents were obtained from parents by research staff before randomization. School teachers, students, and their parents were not blinded from the allocation because of the nature of the intervention. During communication with teachers, parents, and students, the study was framed to be comparing the effectiveness of 2 interventions without mentioning which was the experimental group or which was the comparison group to reduce placebo effects. Research staff scoring questionnaires and analyzing data were blinded from group status.

Intervention

Students in the intervention group received exclusive access to an Internet quiz game on the basis of our successfully tested antismoking quiz game.[16,18] To prevent contamination between the intervention and comparison groups, usernames and passwords unique to each participant were assigned. Participants' access and usage in the Web site were logged. All Web site usage and questionnaire data were linked through 8-digit numbers unique to each participant to ensure data confidentiality.

The intervention spanned 30 days, starting from the day of the school promotion session. The promotion session was a 30-minute briefing by our research staff to introduce the intervention Web site. Participants gained points through answering quiz questions correctly, and those who earned the highest scores won prizes. Alcohol-related multiple-choice questions were presented on the Web page 1 by 1 in random, nonrepeated order. For each correct answer, 10 points were awarded to the participant's account (constituting their "answer scores"). An incorrect answer scored no points and got no point deduction. Users were shown the correct answer immediately after they had chosen an answer. This immediate feedback was to promote correct alcohol-related knowledge. In addition, participants were incentivized to refer the quiz game to anyone in their social circle, such as their parents or their friends outside of school. The referral per se did not add any additional points to the referrers. This is to minimize students making self-referrals. However, referrers' answer score was added toward the referrers' account. The answer score and referral score were summed into a total score that was used for prize distribution. Prizes were book vouchers for the top 10–ranked students in a school. The values of the book vouchers were (in Hong Kong dollars [HK$]) HK$500 (US$64) for rank 1, HK$300 (US$38) for ranks 2 to 3, and HK$100 (US$13) for ranks 4 to 10.

One thousand alcohol-related multiple-choice quiz questions were developed by 4 volunteer medical students (aged 20–22 years) guided by the elaboration likelihood model (ELM) of persuasion.[19] The ELM postulates that people change their attitudes either through the "central route," a deliberate thinking process, or through the "peripheral route," a generic associative process based on the cues of the persuasion. It was suggested that the attitude changes based on the central route would be stronger and longer lasting. The questions were designed to convey accurate yet interesting facts from international and local sources, such as the World Health Organization and Hong Kong Department of Health, and research articles in peer-reviewed journals. To increase the chance for the students to adopt the central route of message processing, the questions were designed to require deliberate analytic thinking and were also concrete, specific, and developmentally appropriate.[20] The research team members with expertise in pediatrics and adolescent development examined and discussed all questions with the question developers to ensure language accuracy and information validity. Finally, the quiz questions were proofread, refined, and approved by 2 independent researchers. Table 1 shows a sample set of 5 quiz questions translated into English for reference. Students were reminded of the quiz game Web site 7 days after the intervention start and 7 days before intervention end.

The questions were presented in blocks so that at least 2 questions from each of the domains would be included in every set of 20 questions. These sources were the same as those used in designing the quiz questions for the Internet intervention. All students in the health education (control) group received a printed leaflet, which included 8 hyperlinks (6 were in Chinese) to alcohol-related online resources. The leaflet summarized alcohol-related health information on basic alcohol facts (eg, units of alcohol), the acute and chronic harm of alcohol drinking (eg, alcohol poisoning and cancer), misconceptions about alcohol (eg, alcohol flush is good physiologic reaction), and ways to quit drinking alcohol (eg, replacing alcohol with noncaffeine drinks).

Outcomes

Alcohol Use

Alcohol use was measured by using a 17-item standardized questionnaire. The 17 items were adapted from the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System Questionnaire and Global School-based Student Health Survey.[21,22] The primary outcomes were 1 item on the 30-day recall frequency and 1 item on the number of units of consumption per day. Additional alcohol-related information was collected with the remaining 15 items, including the number of alcohol-related troubles and the number of times drunk in the past 30 days. The 17-item questionnaire has been used in a national survey in China.[21,22] Any drinking behaviors in the past 30 days at 1-month and 3-month follow-up were the primary outcome variables, whereas the number of units of alcohol per day was a secondary outcome variable.

TABLE 1 Sample Quiz Questions

	Questions
Common misconception of alcohol drinking	
Question	Drinking alcohol can help reduce body weight.
Answers	A: True, B: False
Explanation	A glass of red wine has approximately 200 calories, and some alcoholic beverages have added sugar. Therefore, drinking alcohol cannot help body weight reduction.
Health consequences of alcohol drinking	
Question	Which of the following is NOT a possible consequence of acute alcohol intoxication?
Answers	A: Uncontrollable behaviors, B: Neurologic disorders, C: Respiratory disorders, and D: All of the above
Explanation	Acute alcohol intoxication can lead to uncontrollable behaviors, neurologic disorders, and/or respiratory disorders.
Public health and alcohol drinking	
Question	Globally, how many adolescents aged 15–29 have died because of alcohol-related diseases?
Answers	A: 20 000, B: 120 000, C: 220 000, and D: 320 000
Explanation	320 000 adolescents aged 15–29 died globally because of alcohol-related diseases, ∼9% of all deaths in the age group.
Alcohol-related guidelines/recommendations	
Question	The International Agency for Research on Cancer of the World Health Organization has listed alcohol as a group 2 carcinogen.
Answers	A: True and B: False
Explanation	The International Agency for Research on Cancer in the World Health Organization has listed alcohol as a group 1 carcinogen.
Alcohol-related science/facts	
Question	What is/are the symptom(s) of alcohol flush reaction?
Answers	A: Skin flushes, B: Blotches on skin, C: Headache, and D: All of the above
Explanation	Alcohol flush reaction is common among Asian individuals. People with this reaction will easily develop flushes and blotches on skin, as well as headache. These people are also at a higher risk of esophageal cancer.

Alcohol-Related Knowledge

Nine prespecified true-or-false items were used to assess participants' alcohol-related knowledge. These items included general knowledge about alcohol (eg, "Blushing after drinking alcohol is a healthy phenomenon") and the health and social consequences of alcohol drinking (eg, "Chronic excess drinking will increase risk of oral cancer" and "excess drinking will increase the chance of committing violent behaviors"). The knowledge in these questions was covered in the 1000 quiz questions and in promotional materials provided to the health education group. The number of correct responses (0–9) was the outcome variable used in analyses. There were no significant floor or ceiling effects in this knowledge score.

Perceived Social Norms and Behavioral Control

To explore the potential mechanism of the intervention, the perceived social norms and behavioral control were measured by using a standardized 6-item questionnaire.[23] There was 1 item on the perceived parents' and peers' view on alcohol drinking and 2 items on whether the participants can decide to drink or not. All the items had a 7-point Likert scale.

Confounders

Potential confounders, including relevant school-level (ie, annual tuition fee and number of teachers in the school) and student-level factors (ie, students' age, sex, parental education, and baseline characteristics) were controlled in analyses as covariates.

Statistical Analysis

Data are presented as mean (SD) and frequency (percentage), as appropriate. The baseline characteristics, such as sociodemographics, alcohol use, and knowledge, between 2 groups were compared by using independent samples t tests for continuous data and χ^2 test for categorical data. Generalized linear mixed models were used to examine the intervention effectiveness. Correlation within schools was controlled by using random intercepts. Students' sex, age, parental education, outcome variable measured at the baseline, as well as school annual tuition fee and number of teachers, were included in the model as covariates. The outcome difference between intervention and health education groups was examined by a binary variable that indicated whether a subject belongs to the Internet quiz game intervention arm. Poisson models with robust standard errors[24] were used for binary outcome variables (eg, any drinking in the past 30 days) to estimate risk ratios (RRs), negative binomial models for count variables (eg, number of times having alcohol-

related troubles), and linear models for score-type variables (eg, alcohol-related knowledge). Students' age, sex, and family socioeconomic status (SES) index, as well as annual school fee (as a proxy for school-level SES), were adjusted in the model. A sensitivity analysis was conducted to examine the risk of any alcohol drinking among students who reported no drinking at baseline. Missing follow-up data were imputed, assuming their alcohol-related constructs remain unchanged. Complete-case analysis was conducted to examine any differences in conclusion. All statistical analyses were intention-to-treat, with a prespecified per-protocol analysis used to compare participants who participated in the intervention with those who did not. Analyses were completed by using R statistical program.

Statistical power was calculated a priori on the basis of the primary outcome. Considering the RR of 0.67 (one-third reduction in drinking), a total sample of 145 was needed to achieve 80% statistical power at 0.05 significance level. Because of the present cluster design, and based on intraclass correlation of 0.092,[25] the required sample size increased to 5735 ($N = n \times [1 + (K - 1) \times$ intraclass correlation] $= 145 \times [1 + (3 \times 4 \times 35 - 1) \times 0.092]$, in which K is the average number of students per school.

Patient and Public Involvement

Adolescents were consulted in focus groups in designing this intervention. Their opinions were used to design the interface and content (quiz questions) of the intervention.
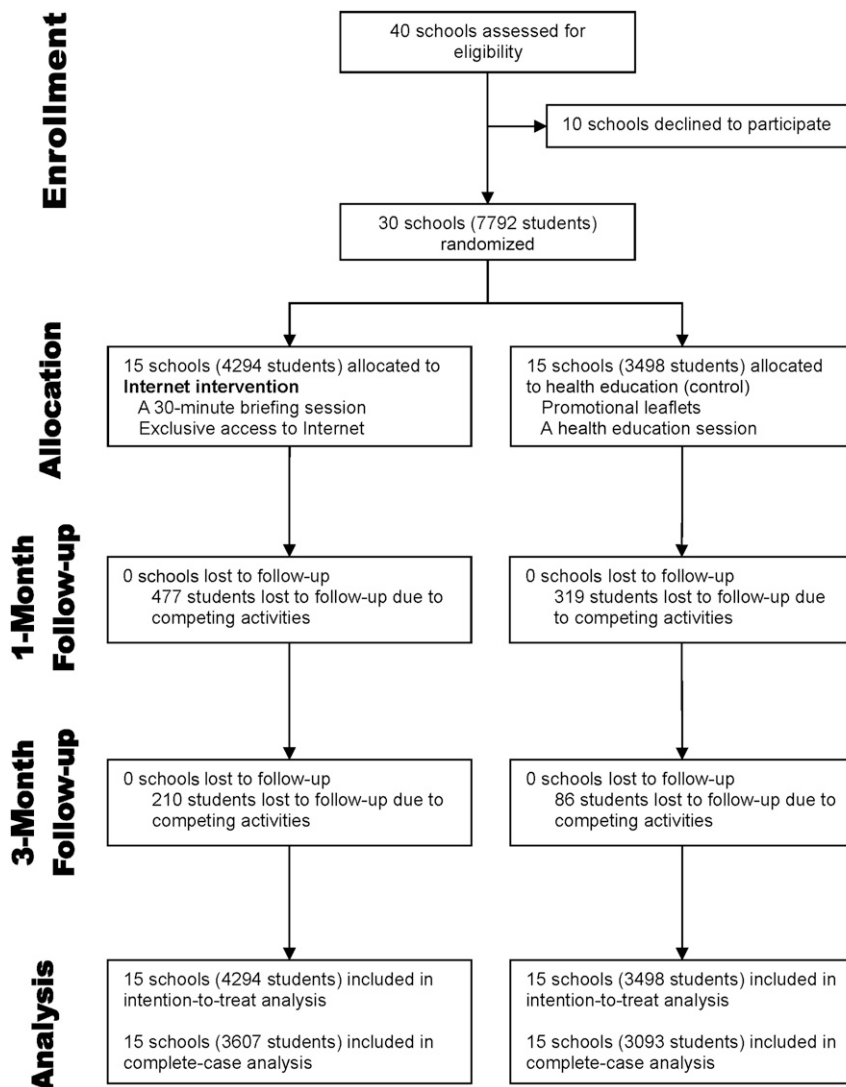
RESULTS

A total of 40 schools from 4 regions in Hong Kong selected from stratified random sampling were assessed for eligibility for this trial;

30 schools agreed to participant and were randomized between August 1, 2015, to September 30, 2015. The remaining 10 schools declined to participate because of not being able to provide the time for the 30-minute promotion session. There were 4294 students from 15 schools in the Internet quiz game intervention group and 3498 students from 15 schools in the health education (comparison) group (Fig 1). The intervention lasted for 1 month, with short-term outcome assessments completed at 1-month follow-up and the medium-term outcome assessment completed at 3-month follow-up. No schools dropped out from the trial. A total 687 (16.0%) students from the intervention group and 405 (11.6%) from the health education group did not complete the medium-term assessment. There were no significant differences in dropout rates between intervention and health education (comparison) groups after adjusting for intraschool correlation ($P = .32$). The overall retention rate at 3-month follow-up for students was 86%. Within the intervention group, 46.0% of the participants accessed the intervention Web sites. No participants in the health education group reported to have accessed the intervention Web site in the postintervention questionnaires.

The baseline characteristics of all participants before intervention are presented in Table 2. The average family income of the participants was HK$27 270 per month, slightly above the population median (HK$25 000[26]). The average age was 13.3 (SD 1.22) years, and girl-to-boy ratio was 1:1.07. The 30-day drinking prevalence was at 13.7%. The average alcohol-related knowledge score was 6.51 out of 9. There were no significant differences between the 2 groups on baseline characteristics.

The intention-to-treat evaluation results are shown in Table 3. At 1-month follow-up, students in the Internet quiz game intervention group showed significantly greater improvements than the health education group (comparisons) on reduced drinking behaviors on multiple indicators. Compared with the comparison group, they were less likely to report drinking (RR 0.79, 95% confidence interval [CI] 0.68 to 0.92; $P = .003$), and they reported lower alcohol consumption (β −0.06, −0.11 to −0.01; $P = .02$) and fewer alcohol-related troubles (0.62, 0.61 to 0.62; $P < .001$). In addition, they perceived their parents (β 0.08, 0.03 to 0.12; $P = .006$) and peers (β 0.06, 0.00 to 0.12; $P = .047$) to be more antialcohol and themselves to have better behavioral control (β 0.11, 0.03 to 0.18; $P = .01$). There was also a trend in improvements of alcohol-related knowledge (β 0.18, −0.01 to 0.36; $P = .07$) relative to comparisons. Complete-case analysis yielded similar results (Supplemental Table 5). No significant moderation of age and sex were identified. Among all students who have not had alcohol at the baseline assessment, those in the intervention group were less likely to report drinking (RR 0.54, 95% CI 0.38 to 0.75; $P < .001$).

The 3 behavioral indicators for alcohol consumption remained statistically significant at 3-month follow-up: the 30-day drinking risk for students in the Internet quiz game intervention group was significantly lower than the health education group (RR 0.86, 0.74 to 0.999; $P = .048$), as was the number of units consumed (β −0.06, −0.11 to −0.01; $P = .02$) and the number of alcohol-related troubles (RR 0.20, 0.08 to 0.51; $P < .001$). The alcohol-related knowledge of the Internet quiz game intervention group was also

FIGURE 1
Study flowchart.

significantly better (β 0.21, 0.03 to 0.39; P = .03). The other contrasts were not statistically significant at 3 months. Complete-case analysis yielded similar results (Supplemental Table 5).

In the per-protocol analysis (Table 4), students in the intervention schools were categorized as participated and not participated on the basis their registration on the intervention Web site. Results show that those who participated were less likely to drink alcohol (RR 0.74, 0.61 to 0.89; P = .001) and drank less

alcohol (β −0.07, −0.13 to −0.01; P = .02). Interestingly, those who did not participate also drank less alcohol 3 months after intervention completion (β −0.06, −0.12 to −0.01; P = .04).

Figure 2 shows the trajectories of 30-day alcohol drinking prevalence across different assessment time points. Both the Internet quiz game and health education groups showed reduced drinking behaviors, but the magnitude of the changes was much higher in the Internet quiz game intervention group.

DISCUSSION

Principal Findings

This is a clustered RCT on the effectiveness of an Internet quiz game intervention in preventing and/or reducing the drinking behavior of Hong Kong adolescents. Both the health education and the Internet quiz game intervention models showed reduced drinking behaviors over 1 to 3 months, but the reduction in the Internet group was 21% and 14% greater at 1- and 3-month follow-up. The intervention was even stronger in preventing alcohol initiation. Among students

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TABLE 2 Baseline Characteristics of All Participants

	Total	Intervention	Comparison	P
Family income, mean (SD), HK$1000[a]	27.27 (27.76)	28.07 (28.47)	26.30 (26.84)	.66
Sex, n (%)				
Girls	3737 (48.0)	2018 (47.0)	1719 (49.1)	.99
Boys	4013 (51.5)	2253 (52.5)	1760 (50.3)	.99
Missing	42 (0.5)	23 (0.5)	19 (0.5)	.99
Age, mean (SD), y	13.30 (1.22)	13.15 (1.17)	13.48 (1.27)	.09
Drinking in past 30 d, n (%)				
No	6721 (86.3)	3709 (86.4)	3012 (86.1)	.44
Yes	1071 (13.7)	585 (13.6)	486 (13.9)	.44
Knowledge, mean (SD)	6.51 (1.61)	6.55 (1.61)	6.46 (1.60)	.80
Number of peers drinking, mean (SD)	3.34 (7.31)	3.65 (7.72)	2.96 (6.77)	.39
Presence of peers drinking, n (%)	3211 (41.2)	1740 (40.5)	1471 (42.1)	.96

[a] US$1 = HK$7.8

who have not had alcohol at baseline, the intervention reduced the risk of drinking by 46% and 27% at 1- and 3-month follow-up. Several secondary outcomes were also significantly improved in the Internet model, including alcohol-related knowledge, perceived behavioral control, and perceived social norms.

Strengths and Weaknesses of the Study

This study has the strengths of using a robust, clustered randomized trial design with a large sample size. In this study, we also compared a promising new intervention model with an active comparison group. Because the sample is recruited through stratified random sampling,

the findings should be generalizable to Hong Kong and regions with similar socioeconomic and cultural contexts. However, the study findings might not generalize to countries outside East Asia. There were several other limitations. First, the randomization of this study was based on schools (clustered RCT) but not the unit of analysis

TABLE 3 Intention-to-Treat Analysis of Intervention Effectiveness

	RR (95% CI)	RD per 100 (95% CI)	β (95% CI)	P
At 1-month follow-up				
Any drinking in past 30 d				
All participants	0.79 (0.68 to 0.92)	−2.64 (−4.07 to −0.97)	—	.003**
Among those not drinking at baseline[a]	0.54 (0.38 to 0.75)	−2.35 (−3.14 to −1.26)	—	<.001***
Units drank per day in the past 30 d	—	—	−0.06 (−0.11 to −0.01)	.02*
Number of alcohol-related troubles	0.62 (0.61 to 0.62)	−0.46 (−0.47 to −0.46)	—	<.001***
Number of times drunk in the past 30 d	0.56 (0.25 to 1.26)	−1.15 (−1.95 to 0.66)	—	.16
Alcohol-related knowledge	—	—	0.18 (−0.01 to 0.36)	.07
Perceived social norm				
Parents	—	—	0.08 (0.03 to 0.12)	.006**
Peers	—	—	0.06 (0.004 to 0.12)	.047*
Perceived behavioral control	—	—	0.11 (0.03 to 0.18)	.01*
At 3-month follow-up				
Any drinking in past 30 d				
All participants	0.86 (0.74 to 0.999)	−1.73 (−3.20 to −0.02)	—	.048*
Among those not drinking at baseline	0.73 (0.55 to 0.96)	−1.62 (−2.65 to −0.26)	—	.02*
Units drank per day in the past 30 d	—	—	−0.06 (−0.11 to −0.01)	.02*
Number of alcohol-related troubles	0.20 (0.08 to 0.51)	−0.94 (−1.08 to −0.58)	—	<.001***
Number of times drunk in the past 30 d	0.54 (0.27, 1.10)	−1.19 (−1.91 to 0.25)	—	.09
Alcohol-related knowledge	—	—	0.21 (0.03 to0.39)	.03*
Perceived social norm				
Parents	—	—	0.04 (−0.03 to 0.10)	.27
Peers	—	—	0.04 (−0.02 to 0.11)	.22
Perceived behavioral control	—	—	0.05 (−0.03 to 0.13)	.26

N = 7792. All results were adjusted for students' sex, age, family SES index, annual school fee, and corresponding baseline attributes as covariates and intraschool correlation as random intercept. RRs for binary outcomes were estimated by using Poisson mixed models with robust SEs; RRs for count outcomes were estimated by using negative binomial mixed models. RDs (Risk$_{intervention}$ − Risk$_{control}$) per 100 are based on RR and absolute risk of the control group. RD, risk difference; —, not applicable because of analysis method.

[a] N = 6721.
*P < .05.
**P < .01.
***P < .001.

TABLE 4 Per-Protocol Analysis of Between-Group Differences 3 Months After the Completion of Intervention

	Intervention Effect (95% CI)	P
At 1-month follow-up		
Any drinking in past the 30 d, RR		
Participated	0.74 (0.61 to 0.89)	.001**
Not participated	0.87 (0.71 to 1.06)	.17
Units drank per day in the past 30 d, β		
Participated	−0.07 (−0.13 to −0.01)	.02*
Not participated	−0.05 (−0.11 to 0.00)	.06
At 3-month follow-up		
Any drinking in past the 30 d, RR		
Participated	0.84 (0.70 to 1.01)	.06
Not participated	0.88 (0.72 to 1.07)	.21
Units drank per day in the past 30 d, β		
Participated	−0.06 (−0.12 to 0.00)	.046*
Not participated	−0.06 (−0.12 to −0.01)	.04*

Per-protocol analysis was used to compare participants who accessed the Internet intervention with those randomly assigned to the control group. All results were adjusted for students' sex, age, family SES index, annual school fee, and corresponding baseline attributes as covariates and intraschool correlation as random intercept. RRs for binary outcomes were estimated by using Poisson mixed models with robust SEs, and β was estimated by using linear mixed models.
** $P < .01$.
* $P < .05$.

(students) so residual confounding was possible. Individual randomization was not ideal in this study because it would lead to contamination by the intervention of the health education group. Second, only 46.0% of the participants randomly assigned to the Internet quiz game intervention accessed the Web site, and there were no other participation statistics due to technical difficulties. This may have produced an underestimated intention-to-treat effect size. Third, 14.0% of students did not participate in the final assessment at 3-month follow-up. The cited reasons for nonresponses were being busy with schoolwork and other competing extracurricular activities, which was unlikely to have high correlation with drinking-behavior outcomes. We accounted for this by using intention-to-treat analysis, assuming missing cases did not show any improvements, and the effect size shown could be underestimated. Furthermore, the participants were not blinded from the intervention allocation, and participants in the interventions may feel pressured to report fewer drinking behaviors. Because of the design of this intervention, it is not possible to evaluate which component of the intervention
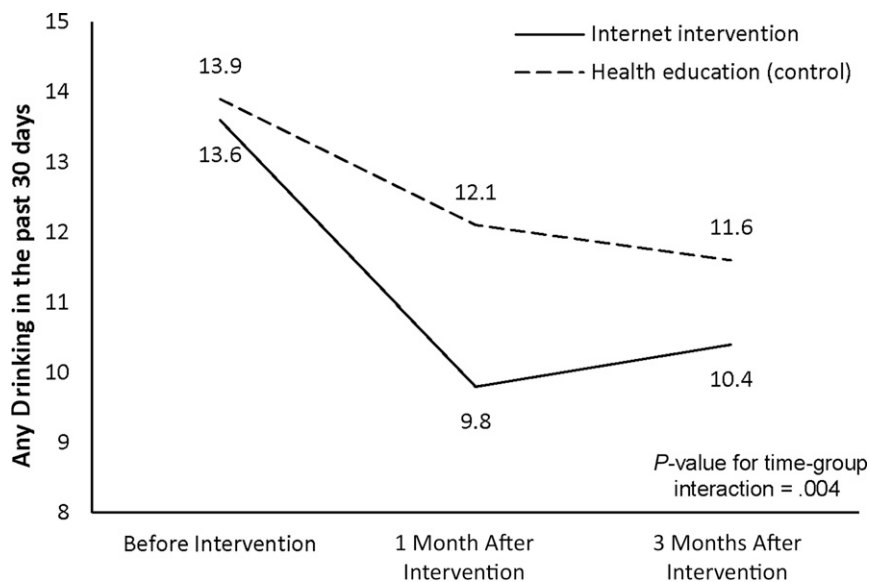
FIGURE 2
Prevalence of alcohol drinking at baseline and 1- and 3-month follow-up.

contributes to the effect. Owing to practical concerns, some outcomes (eg, alcohol-related knowledge) were assessed by using relatively brief tools, which might lower its precision. Lastly, because of privacy concern, in the current study, we did not record any contact information of the students, and the trial assessments were completed with the assistance of schoolteachers via pseudonyms. This prevented longer-term follow-up of this trial.

Strengths and Weaknesses in Relation to Other Studies

In conventional interventions targeting adolescent drinking problems, researchers often use motivational interviews (which are much more intensive), but the results have been mixed. For example, an RCT in the United States with 152 adolescents aged 13 to 17 years in an emergency department showed that those who received motivational interviews did not have significantly better alcohol-related behaviors at 12 months postintervention compared with those who received standard care. The only significant difference was found in a subgroup analysis on those with severe alcohol-drinking problems.[27] In another RCT in the United States, researchers compared a 35-minute therapist-led motivational interview to a promotional pamphlet (comparison condition) using a larger sample of 3338 adolescents.[28] The intervention showed greater reduction in peer aggregation and victimization but no significant benefit on self-report drinking behaviors. Interestingly, that trial also had an intervention arm of interactive computer animation, which did not show any benefits in violence and alcohol misuse compared with the promotional pamphlet.[28] The null effect is consistent with a previous brief,

computer-based RCT[27] but contrasts with the positive findings of our cluster RCT. There could be several explanations for the difference. First, the previous 2 computer interventions were relatively brief and therefore might not be sufficient to change behaviors, whereas the present Internet quiz game intervention had more in-depth content regarding the problems of underage drinking and alcohol misuse. Second, both previous trials were individualized, whereas our quiz game competition could promote social interaction outside the Web site through its referral mechanism. This might have promoted a positive social norm among the participants, which is a strong predictor for future behaviors.[29] It was also possible that the current study used the ELM to engage participants' central route processes through multiple-choice questions with mental effort, which could provide a more impactful and sustained effect.[19]

Meaning of the Study

It is interesting to note that participants in both groups had comparable levels of alcohol-related knowledge at 1-month follow-up, but the difference increased and became statistically significant at 3-month follow-up. This contrasts with a previous meta-analysis that showed the effect of computer-based interventions tend to fade in a couple of weeks.[30] We should, however, note that the short-term effect identified in our trial was a relative difference between the Internet quiz game intervention and the health education (comparison) and that health education could also lead to better alcohol-related constructs over time. The trajectories showed that alcohol-related knowledge in both groups improved from baseline to the 1-month evaluation, but the improvement in the health

education group declined rapidly at 3-month follow-up, whereas the improvement in the Internet quiz game intervention group was sustained. Hence, although both the conventional and the new intervention models could improve alcohol-related knowledge transiently, the Internet quiz game did better on knowledge retention, albeit with a modest effect size. This might be related to the emphasis of central route processes in designing the questions of the Internet quiz game intervention.[19] Nonetheless, it is still of interest to understand how the improvements on behavioral and knowledge indicators can be sustained a longer period of time (eg, 1 year after intervention). In this trial, only 46% of the students randomly assigned to the intervention group actually accessed the Web site. In future studies, researchers should investigate means to improve engagement and whether the true effect is stronger than illustrated in this study.

Although the effect sizes seem modest, and the individual-level benefits of this intervention might be limited, scaling up this relatively low-cost (maintenance cost HK$10 000, equivalent to US$1282) intervention widely may still achieve population-level benefits.

CONCLUSIONS

This clustered RCT indicates the effectiveness of an Internet quiz game intervention in comparison to conventional health education. The drinking behavior of adolescents in the Internet group declined significantly more than the comparison group at 1-month follow-up. The beneficial effect was sustained at 3-month follow-up. This model may serve as a public health intervention model to tackle underage drinking in the future.

ABBREVIATIONS

CI: confidence interval
ELM: elaboration likelihood model
HK$: Hong Kong dollar
RCT: randomized controlled trial
RR: risk ratio
SES: socioeconomic status

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