Published in final edited form as:
Addiction. 2009 November ; 104(11): 1807–1819. doi:10.1111/j.1360-0443.2009.02691.x.

Computer-Delivered Interventions to Reduce College Student Drinking: A Meta-Analysis

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Abstract

Aims—This meta-analysis evaluates the efficacy and moderators of computer-delivered interventions (CDIs) to reduce alcohol use among college students.

Methods—We included 35 manuscripts with 43 separate interventions, and calculated both between-group and within-group effect sizes for alcohol consumption and alcohol-related problems. Effects sizes were calculated for short-term (≤ 5 weeks) and longer-term (≥ 6 weeks) intervals. All studies were coded for study descriptors, participant characteristics, and intervention components.

Results—The effects of CDIs depended on the nature of the comparison condition: CDIs reduced quantity and frequency measures relative to assessment-only controls, but rarely differed from comparison conditions that included alcohol content. Small-to-medium within-group effect sizes can be expected for CDIs at short- and longer-term follow-ups; these changes are less than or equivalent to the within-group effect sizes observed for more intensive interventions.

Conclusions—CDIs reduce the quantity and frequency of drinking among college students. CDIs are generally equivalent to alternative alcohol-related comparison interventions.

Keywords

alcohol use; prevention; computer-delivered intervention; college students; meta-analysis

INTRODUCTION

Most college students (80%) drink alcohol, even though the majority cannot legally purchase alcohol; many also report binge drinking, alcohol-related problems, and drinking to get drunk [1]. These drinking patterns have been identified as a public health problem by the Surgeon General [2], Institute of Medicine [3], and the National Center on Addiction and Substance Abuse [4], and reducing binge drinking in college students is a goal in Healthy People 2010 [5]. Controlled studies of college alcohol interventions are increasing [6] and, within this literature, computer delivery of prevention interventions is appealing due to its ease of administration and lower cost [7].

The use of computers to deliver alcohol “counseling” offers many appealing features, especially to students. Computer-delivered interventions (CDIs) allow students to access information at a self-determined pace while maintaining privacy. Technology permits

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Conflict of Interest: This work was supported by National Institute on Alcohol Abuse and Alcoholism Grants K02-AA15574 and R01-AA12518 to Kate B. Carey. The authors have no conflict of interest related to this research.

personalization of content and the potential for using multimedia, games and virtual simulations to engage emerging adults. Compared to interventions that require counselors, CDIs reach more students [8]; this potential for dissemination affords greater reach to a significant subset of the population.

A 2005 review of CDIs for students described five programs but evaluation data were limited to two randomized controlled trials (RCTs) [9]. By 2008, Elliott, Carey, and Bolles [10] reviewed 17 controlled trials of CDIs for college drinkers, and concluded that CDIs were more efficacious than assessment-only controls, but often equivalent to alternate interventions. The rapid growth of research on CDIs for students now permits a quantitative review of this literature.

The primary purpose of this meta-analytic review is to generate effect sizes that reflect (*a*) the efficacy of CDIs relative to comparison conditions and (*b*) within-groups change. A secondary purpose is to explore the (*c*) efficacy of CDIs relative to active controls, and (*d*) maintenance of effects over time. We also explore (*e*) moderators of efficacy of CDIs (e.g., intervention length).

METHODS

Search Strategy and Study Selection

Studies were retrieved from (*a*) electronic databases (PubMed, PsycINFO, CINAHL, Dissertation Abstracts, ERIC, Cochrane Library, CRISP) using a Boolean search strategy that includes the use of operators (i.e., and, or, not) and truncation (using an asterisk) to link and expand specific keywords (search terms: alcohol/drink*/binge and college/university/undergraduate* and intervention/prevention and computer/internet/intranet/DVD/email/text*), (*b*) reference sections of manuscripts, (*c*) online contents of journals (e.g. *Addiction*), and (*d*) responses to listserv requests. Unpublished papers were included to avoid the file-drawer effect (i.e., stronger effects reported in published studies; [11]). Studies were included if they (*a*) examined an alcohol-related intervention delivered via computer or electronic device (e.g., text messages), (*b*) sampled undergraduates, (*c*) assessed behavioral outcomes; and (*d*) provided sufficient information to calculate effect sizes. When authors reported outcomes in multiple manuscripts, the studies were linked and represented as one study. If a study reported on more than one comparison condition (e.g., standard education and assessment only), the condition with the least contact was used. In some cases, comparisons were made with an active non-CDI when a less-intensive control condition was unavailable. Authors of 17 studies reporting insufficient details were contacted for additional information (83% response rate resulting in the retention of 14 studies). Using these methods, we included 35 manuscripts with 43 separate interventions (Fig. 1).

Study Outcomes

We examined alcohol consumption and problems. A*lcohol consumption* included: (1) quantity consumed over time (e.g., week, month), (2) quantity per drinking occasion (e.g., Friday night), (3) maximum quantity consumed on one occasion, (4) frequency of heavy drinking (usually defined as ≥5 drinks for men and ≥4 drinks for women [12], and (5) frequency of drinking days. *Alcohol-related problems* were operationalized using multi-item scales.

Content Coding and Reliability

Study information (e.g., publication year), sample characteristics (e.g., gender, age), target group (e.g., Greek members, freshmen), design and measurement specifics (e.g., recruitment method), and content of intervention and control condition(s) (e.g., number of sessions,

content) were coded independently by two of the authors. (Appendix 2 contains a complete list of coding categories.) Methodological quality was assessed using 12 items adapted from validated measures [13, 14]; scores ranged from 0 to 17. Fifteen studies were randomly selected to evaluate interrater reliability. For the categorical dimensions, raters agreed on 56% to 100% of the judgments (mean Cohen's kappa = .72). Reliability for the continuous variables was calculated using the intraclass correlation coefficient (ICC); ICC ranged from .82 to 1.00, with an average of .98 across categories. Disagreements were resolved through discussion.

Effect Size Derivation

Effect sizes (*d*) were calculated as the mean difference between the CDIs and control group divided by the pooled standard deviation (SD) [15] or from other statistical information (e.g., independent *t*-tests) when the means and SDs were unavailable [16]. If authors reported dichotomous outcomes, we calculated an odds ratio and transformed it to *d* using the Cox transformation [17]. In addition, effect sizes were calculated for time-related change within each group as the mean difference between the post- and pre-test divided by the SD of the paired comparisons [18]. If statistical information could not be obtained from the authors and the study reported no significant group differences, we estimated that effect size to be zero for between-group effect sizes [16]. In calculating *d*, we controlled for baseline differences when pre-intervention measures were available, and effect sizes were corrected for sample size bias [19]. We calculated multiple effect sizes from individual studies when they had more than one outcome, multiple CDIs, or when outcomes were separated by sample characteristics (e.g., gender). Effect sizes calculated for each intervention and by sample characteristic were analyzed as a separate study [16]. When a study contained multiple measures of the same outcome (e.g., weekly and monthly alcohol consumption), the effect sizes were averaged. A positive sign indicated that the CDIs improved compared to controls or participants improved at post-test relative to pre-test. Two authors independently calculated effect sizes using DSTAT 2.0 [20]; discrepancies were examined for errors and corrected.

Statistical Analysis

Weighted mean effect sizes, d_+, were calculated using fixed- and random-effects procedures [16], such that individual studies' effect sizes were weighted by the inverse of their fixed- or random-effects variance. One study had an extremely large sample size relative to others [21], and these data exerted undue influence on the d_+ calculations for three dependent variables (i.e., quantity of alcohol consumed, frequency of heavy drinking, alcohol-related problems at short-term). We retained the study in the analyses by recoding the unrepresentative sample size weights to be equivalent to the next smallest weight within each dependent variable (i.e., windsorizing [16]).

The homogeneity statistic, *Q*, was computed to determine whether each set of d_+s shared a common effect size; a significant *Q* indicates that additional variability, beyond subject-level sampling error, can be explained [16]. In addition, the I^2 index was calculated to assess the proportion of variability in a set of effect sizes attributable to true heterogeneity [22,23]. Percentages of 25%, 50%, and 75%, are considered low, medium, and high heterogeneity, respectively [24]. If the 95% confidence interval around the I^2 index includes zero, the set of effect sizes are considered homogeneous. To explain variability in the effect sizes, the relation between study characteristics and the magnitude of the effects was examined using a modified least squares regression analyses with weights equivalent to the inverse of the variance for each effect size. To examine pre to post differences between groups, we calculated the between-groups-of-studies measure, Q_B, which is the weighed sum of squares

of group mean effect sizes about the grand mean effect size [25]. Analyzes were conducted in Stata 10.0 [26] using macros provided by Lipsey and Wilson [16].

RESULTS

Descriptive Outcomes

Study and participant characteristics, research design, and intervention and comparison condition details are reported in Appendix 1; complete descriptive statistics are reported in Appendix 2. Of the 28,621 participants, 75% were White, 68% first year students, and mean age was 19.71 (SD = 1.09). Half (54%) volunteered; 33% were recruited with targeted efforts and 14% were mandated to participate. Most studies (94%) targeted the intervention to an at-risk group; studies targeted heavy drinkers (28%), freshman (23%), high-risk drinkers (18%), violators of alcohol policy (13%), and current drinkers (13%).

The typical intervention (*k*) was a single-session computerized task delivered via the internet (38%), intranet (30%), or CD-ROM/DVD (25%) lasting a median of 20 minutes. Most CDIs were delivered onsite (72%), whereas 24% of students completed the CDI offsite. Most were investigator-developed; only 41% used commercial programs. Interventions usually included consumption feedback (86%) and normative comparisons (77%), alcohol education (77%) and tailored materials (61%). The comparison condition consisted of wait-list/no treatment control for 43% of the comparisons; 51% presented alcohol-related content (e.g., alcohol education).

The median number of post-intervention assessments was 1 (range = 1 to 3); the first assessment occurred between 0 to 26 weeks, the second between 1 and 52 weeks, and the third between 2 and 52 weeks. To avoid violating the assumption of independence, effect sizes were clustered into (a) short-term (≤ 5 weeks; $k = 43$), and (b) long-term (≥6 weeks; $k = 14$).

Intervention Impact Compared with Controls

At short-term follow-up (≤ 5 weeks), students who received a CDI reduced quantity of alcohol consumed on specific intervals/drinking days and the maximum quantity consumed (see Table 1). CDI participants did not differ from controls on quantity of alcohol consumption, frequency of heavy drinking or drinking days, or alcohol-related problems (effects were parallel using fixed- and random-effects assumptions). The hypothesis of homogeneity was rejected only for alcohol-related problems; examination of the I^2 index confirmed a moderate level of heterogeneity. Moderator tests were conducted to examine whether study features related to the variability (reported below).

At long-term follow-up (≥ 6 weeks) students receiving a CDI reduced their quantity of alcohol consumed, frequency of drinking days, and alcohol-related problems relative to controls. CDIs and controls were equivalent on measures of quantity at specific intervals/ drinking days, maximum quantity, and frequency of heavy drinking (effects were parallel using either fixed- or random-effects assumptions). The hypothesis of homogeneity was rejected only for frequency of heavy drinking (I^2 index = 62%, 95% CI 21%–82%); moderator tests were conducted on frequency of heavy drinking at long-term follow-up (reported below).

Supplemental analyses—Controls were categorized as having relevant content (i.e., alcohol-related content including education only) vs. non-relevant content (i.e., wait-list/ assessment only or content unrelated to alcohol use). Alcohol-relevant content included alternative delivery (e.g., print or lecture) of the same content (21%), a face-to-face tailored

comparison (29%; e.g., brief motivational interview or cognitive behavioral therapy), a non-tailored version delivered via computer (36%), or education-only (14%). Most of the non-relevant controls consisted of wait-list/assessment only conditions (94% at short-term, 100% at long-term).

Compared to participants exposed to a non-relevant control condition, CDI participants reduced their consumption (quantity and quantity at specific intervals/drinking days), frequency of heavy drinking, and frequency of drinking days in the short-term (see Table 2); at long-term they reduced quantity of consumed, and frequency of drinking days. In contrast, compared with control conditions containing alcohol-relevant content, participation in a CDI did not result in less consumption at short-term or long-term. The only comparison favoring participants in the CDIs vs. alcohol-relevant controls was problems at long-term. To explore this finding, we removed alcohol education from "relevant control" and recoded these conditions as "non-relevant control" (3 education-only comparisons), consistent with reviews that demonstrate education alone to be ineffective for changing drinking [27,28]. After this recoding, the average effect size for CDIs vs. relevant controls at long-term for problems, $k = 3$, becomes non-significant ($d_+ = -0.01$, 95% confidence interval [CI] = −0.22–0.25), and the corresponding effect size for the CDIs vs. non-relevant controls, $k = 8$, becomes significant ($d_+ = 0.20$, 95% CI = 0.09–0.30). This pattern corresponds to the other outcomes at long-term follow-up. (Details of this analysis are available from the authors.)

Moderators of Alcohol Consumption at Short- and Long-term Assessment

Potential moderators of intervention impact were examined using weighted regression analyses. Characteristics of the studies (e.g., published vs. unpublished), samples (e.g., gender), and intervention (e.g., length) as well as study quality were entered as predictors of alcohol consumption variables (see Appendix 2 for study, sample, and intervention characteristics used in the analyses). We examined the intervention impact of alcohol-related problems at short-term and frequency of heavy drinking at long-term compared with any type of control condition (i.e., both non-relevant and relevant comparisons are included).

Alcohol-related problems at short-term assessment—CDIs were more successful when the study was published earlier (β = −0.61, $p = .01$; Q_{Residual} (1) = 5.95, $P = .01$), did not use a commercially available program (β = −0.47, $p = .04$; Q_{Residual} (1) = 4.15, $P = .04$), included human interaction vs. using the computer alone (β = −0.53, $p = .02$; Q_{Residual} (1) = 5.15, $P = .02$), and provided general alcohol-related materials (e.g., brochures) to participants (β = 0.53, $p = .02$; Q_{Residual} (1) = 5.15, $P = .02$).

Frequency of heavy drinking at long-term assessment—CDIs were more successful at reducing heavy drinking frequency at long-term when they were published earlier (β = −0.77, $P < .001$; Q_{Residual} (1) = 12.29, $P < .001$), included fewer students (β = −0.93, $P < .001$; Q_{Residual} (1) = 18.15, $P < .001$), and did not provide feedback on alcohol-related problems (β = −0.63, $P < .01$; Q_{Residual} (1) = 8.21, $P < .01$).

Within-Group Changes Over Time

As shown in Table 3, exposure to a CDI reduced all measured outcomes relative to baseline scores at short-term follow-up (≤ 5 weeks); within-group effect sizes ranged from 0.14 to 0.32. Again, the comparison groups were stratified by relevancy. Participants receiving a non-relevant control tended not to change over time, reducing only their quantity of drinking on specific intervals/drinking days ($d_+ = 0.22$) while increasing their frequency of heavy drinking ($d_+ = -0.17$). In contrast, participants exposed to a relevant control condition showed significant improvement on all outcomes (d_+s = 0.19 to 0.34) at short-term.

To examine variation in improvement across the CDIs and control groups, we calculated Q_B. Compared to non-relevant controls, CDI participants reduced quantity consumed (mean = 0.17, SE = 0.04 vs. mean = 0.02, SE = 0.08), frequency of heavy drinking (mean = 0.14, SE = 0.04 vs. mean = −0.17, SE = 0.06), and alcohol-related problems (mean = 0.14, SE = 0.05 vs. mean = −0.24, SE = 0.07), Q_B = 4.22, 24.00, and 24.94 respectively, *P*s ≤ 04. Compared to relevant controls, CDIs were *less* successful in reducing frequency of heavy drinking (mean = 0.14, SE = 0.04 vs. mean = 0.28, SE = 0.06) and alcohol-related problems (mean = 0.14, SE = 0.05 vs. mean = 0.34, SE = 0.08), Q_B = 4.94 and 4.42 respectively, *P*s <. 04.

At long-term follow-up (≥ 6 weeks), receiving a CDI reduced quantity of alcohol consumed, maximum quantity, and frequency of heavy drinking relative to baseline; within-group effect sizes ranged from 0.22 to 0.32. CDI participants did not reduce quantity consumed on specific intervals/drinking days, frequency of drinking, or alcohol-related problems at long-term follow-up. No significant long-term effects were found among participants exposed to a non-relevant control; however, participants in relevant comparison groups reported reductions on all measures of alcohol consumption (d_+s = 0.27 to 0.69) except for alcohol-related problems (d_+ = 0.09) at long-term.

The between-groups test (Q_B) again revealed differential improvement at long-term follow-up. Compared with non-relevant controls, CDIs produced greater reductions in quantity (mean = 0.32, SE = 0.05 vs. mean = 0.05, SE = 0.07) and maximum quantity (mean = 0.22, SE = 0.05 vs. mean = 0.01, SE = 0.06), Q_B = 12.01 and 7.62 respectively, *P*s <.01. Compared with relevant controls, CDIs produced less change in quantity at specific intervals/drinking days (mean = 0.08, SE = 0.05 vs. mean = 0.27, SE = 0.07), maximum quantity (mean = 0.22, SE = 0.05 vs. mean = 0.69, SE = 0.11), and frequency of drinking days (mean = 0.09, SE = 0.06 vs. mean = 0.29, SE = 0.08), Q_B = 5.06, 21.77, and 4.42 respectively, *P*s ≤ .04.

DISCUSSION

This meta-analysis summarizes the efficacy of CDIs for college students, across alcohol use outcomes and assessment intervals. We presented both between- and within-group effect sizes to elucidate change resulting from CDIs. Overall, results provide qualified support for the efficacy of CDIs to reduce alcohol use and problems in college students.

CDIs are associated with improvement over time, and produce greater risk reduction than no intervention. Relative to assessment-only controls, CDIs reduced both quantity and frequency measures of consumption; the observed effects are small (0.09 to 0.28) over short- and long-term intervals [15]. In comparison, CDIs evaluated in other populations yield an average effect size of 0.24 at first measurement occasion [29]. Thus, CDIs targeted to students provide effects (relative to no treatment) similar to those found in the general population.

Improvements over time varied across outcomes. Between-groups effects on specific consumption outcomes (quantity per drinking day and/or specific drinking occasions and maximum quantity) were observed at short-term (≤ 5 weeks), but did not persist at the long-term assessment. In contrast, reduction in quantity consumed over a period of time (e.g., weeks, months) was observed only at long-term assessment. Consistent with the Transtheoretical Model [30], delayed reductions in alcohol consumption are likely due to a person's readiness (and ability) to make necessary changes. Thus, reduction in average quantity consumed may occur incrementally whereas consumption patterns occurring less frequently (e.g., holidays) may be more amenable to immediate change. With respect to

alcohol-related problems, CDIs were efficacious at improving long- but not short-term problems, consistent with prior research examining controlled alcohol interventions [6]. The lower base rate of problems (relative to drinking occasions) may require more time for reductions in problems to be observed.

Evidence for the efficacy of CDIs depends upon the comparison condition. Relative to CDI vs. no-treatment controls, CDI vs. active comparisons yielded smaller effects [cf, 31]. In this study, relevant comparison conditions varied with regard to content and intensity; in some cases, the comparison conditions were empirically-validated, counselor-delivered interventions. The small number of comparisons with specific forms of alternative interventions prevents conclusions about the efficacy of CDIs to relative to specific active interventions but supports the conclusion that CDIs did not differ from these alcohol-focused interventions.

Within-group effect sizes afford stronger conclusions: Whereas true controls tended not to change over time, CDI recipients reduced risk over time. Improvement is more consistent at short-term assessments. Research is needed to explain the inconsistent findings at long-term. Not surprisingly, participation in other active alcohol interventions was associated with improvement. In a review of web-based interventions (not restricted to college students), Bewick and colleagues [33] reported a similar pattern: equivalent change over time for both web and alternative intervention conditions. Comprehensive reviews of alcohol interventions reveal that drinking is responsive to motivational [32] and other brief interventions [28]; if they produce equivalent outcomes, CDIs offer a cost-effective alternative to counselor-delivered interventions.

Despite the variability in the CDIs we sampled, few outcomes met formal tests of heterogeneity with enough studies to support moderator analyses. Furthermore, we evaluated many features of the samples, designs, and interventions, but few explained variability in effect sizes. Relative to alternatives, CDIs produced stronger effects in earlier publications, in studies with fewer participants, and when a commercial program was not used. These trends suggest as evaluation trials become larger and greater dissemination is achieved, the likelihood of detecting differences between CDIs and alternatives is reduced (consistent with the transition from efficacy to effectiveness [34]).

Limitations of the Review

Too few studies were available to allow strong inferences regarding (*a*) trends over time, (*b*) efficacy of specific CDIs, and (*c*) moderators of alcohol consumption or problems. First, most studies in the meta-analysis included only one post-intervention assessment, and fewer evaluated outcomes beyond 6 weeks. Thus, fewer comparisons were available for longer follow-ups, limiting opportunities to assess the stability of change. Moreover, variability in the length of follow-ups (i.e., 6 to 52 weeks) may have influenced our findings, making inferences more challenging. That is, it is unclear whether these improvements persist or represent more intermediate change. A prior meta-analytic review of alcohol interventions found reductions in consumption until 6 months whereas improvements in alcohol-related problems persisted longer [6]. Second, CDI refers to delivery mode but other features (e.g., content, structure, interactivity) may be important and varied across studies. The limited comparisons available on any dimension preclude further evaluation of the unique relationship of individual components to efficacy. Finally, the small number of studies did not support multivariate predictor models that would allow evaluation of interactions among moderators.

Future Research

Future research might address issues of study design, optimizing efficacy, and understanding mechanisms of delivery. First, it will be informative to evaluate maintenance of gains associated with CDIs more systematically; studies should include more and longer follow-ups. Drinking varies over the academic year as a function of academic demands and breaks [36], so more assessment occasions will provide greater power to detect change. Second, systematic comparisons of CDIs to alternatives that vary in intensity (e.g., brief vs. intensive face-to-face) and cost would be informative. Such data can provide a clearer picture of the added value of CDIs over alternative interventions. Such comparisons will allow incremental cost-effectiveness analyses (see [37,38]) to supplement traditional outcome analyses. Third, research evaluating CDIs should identify the components that account for observed outcomes. Several studies provide evidence that reductions in perceived drinking norms mediate the effects of feedback-based CDIs (e.g., [39–41]). As recently suggested, computer tailoring technologies range from personalized health assessments with feedback to CDIs in which content is individualized based on complex algorithms [42]. Research on CDIs for college student drinkers might benefit from interventions developed for other health behaviors.

Fourth, studies might be designed to match individuals with intervention modalities. For example, a recent study revealed that females respond more favorably to the counselor-administered intervention whereas males respond equivalently to computer- and counselor-administered interventions [43]. In addition, preference for CDIs and cognitive learning styles might be studied to optimize web-based learning tools [44]. Alternately, low levels of motivation might favor face-to-face interventions, as certain counseling styles can reduce resistance and enhance outcomes [45,46].

Finally, as the number of evaluation studies increase, meta-analyses will be able to evaluate the delivery mechanisms that moderate the impact of CDIs on alcohol consumption and problems such as on-site vs. off-site, CD-ROM vs. Internet, and single vs. multiple computer-delivered modes. For example, on-site delivery may result in greater intervention compliance than remote delivery.

CONCLUSIONS

CDIs produce significant change over time on measures of quantity and frequency of drinking in college samples. Clear patterns of improvement emerged at short-term (≤ 5 weeks); estimates of long-term improvement are qualified by fewer studies on which to base effect sizes. CDIs are clearly preferable to no intervention, and they are generally equivalent to alternative alcohol-related interventions. Once developed, CDIs are available for modest (or no) cost, providing researchers access to standardized alcohol-related interventions. Despite the availability of CDIs, few standardized programs have undergone rigorous evaluation. Policy decisions will benefit from systematic comparisons of CDIs (commercially available and newly developed) against alternate interventions of varying intensity, determination of active ingredients of CDIs, and attention to person-by-intervention interactions.

Acknowledgments

We thank the following study authors for providing manuscripts and/or additional intervention or statistical information: Nancy P. Barnett, PhD, Christopher J. Correia, PhD, Diana M. Doumas, PhD, William M. Hunt, PhD, Kypros Kypri, PhD, James E. Lange, PhD, Thad R. Leffingwell, PhD, Melissa A. Lewis, PhD, Michelle J. Moore, PhD, Clayton Neighbors, PhD, and Richard Saitz, MD.

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Table 1

Weighted mean effect sizes and homogeneity statistics for the CDIs by follow-up interval*

		Weighed mean *d* (and 95% CI)		Homogeneity of effect sizes		
Outcome	***k***	**Fixed effects**	**Random effects**	**Q**	***P***	**I^2 (95% CI)**
Short-term Follow-up (≤5 weeks)						
Quantity	20	0.07 (−0.02, 0.16)	0.09 (−0.03, 0.21)	28.71	.070	34% (0%, 61%)
Quantity, specific intervals/drinking days	25	**0.10 (0.01, 0.20)**	**0.10 (0.01, 0.20)**	9.49	.996	0%
Maximum quantity	7	**0.16 (0.01, 0.31)**	**0.16 (0.01, 0.31)**	3.30	.770	0%
Frequency of heavy drinking	12	0.10 (0.00, 0.20)	0.13 (−0.01, 0.27)	19.16	.058	43% (0%, 71%)
Frequency of drinking days	17	0.11 (−0.01, 0.23)	0.10 (−0.04, 0.25)	20.61	.194	23% (0%, 57%)
Problems	10	0.10 (−0.02, 0.22)	0.16 (−0.02, 0.34)	**18.55**	**.029**	**51% (1%, 76%)**
Long-term Follow-up (≥6 weeks)						
Quantity	12	**0.15 (0.05, 0.25)**	**0.15 (0.05, 0.25)**	8.43	.674	0%
Quantity, specific intervals/drinking days	6	0.08 (−0.05, 0.22)	0.08 (−0.05, 0.22)	3.88	.567	0%
Maximum quantity	7	0.03 (−0.10, 0.16)	0.02 (−0.12, 0.16)	6.85	.335	12% (0%, 55%)
Frequency of heavy drinking	9	−0.10 (−0.20, 0.01)	−0.06 (−0.24, 0.11)	**20.98**	**.007**	**62% (21%, 82%)**
Frequency of drinking days	7	**0.16 (0.03, 0.29)**	**0.16 (−0.00, 0.32)**	9.28	.159	35% (0%, 73%)
Problems	11	**0.16 (0.06, 0.25)**	**0.16 (0.06, 0.25)**	6.54	.768	0%

*CDIs, computer-delivered interventions. *k*, number of interventions. *d*, weighted standardized mean difference. CI, confidence interval. Boldface text highlights significant values.

Table 2

Weighted mean effect sizes for the CDIs by follow-up interval and control type*

	CDIs vs. Non-Relevant Controls			CDIs vs. Relevant Controls		
Outcome	***k***	**Fixed effects d_+ (95% CI)**	**Random effects d_+ (95% CI)**	***k***	**Fixed effects d_+ (95% CI)**	**Random effects d_+ (95% CI)**
Short-term Follow-up (≤ 5 weeks)						
Quantity	10	**0.16 (0.01, 0.31)**	0.19 (−0.01, 0.38)	10	0.01 (−0.11, 0.13)	0.01 (−0.14, 0.16)
Quantity, specific intervals/drinking days	11	**0.15 (0.01, 0.28)**	**0.15 (0.01, 0.28)**	14	0.06 (−0.08, 0.20)	0.06 (−0.08, 0.20)
Maximum quantity	1	--	--	6	0.15 (−0.01, 0.31)	0.15 (−0.01, 0.31)
Frequency of heavy drinking	6	**0.21 (0.07, 0.35)**†	**0.29 (0.05, 0.52)**	6	−0.01 (−0.15, 0.14)	−0.01 (−0.15, 0.14)
Frequency of drinking days	4	**0.19 (0.01, 0.37)**	0.22 (−0.08, 0.51)	13	0.06 (−0.10, 0.21)	0.06 (−0.10, 0.21)
Problems	6	0.11 (−0.03, 0.26)	0.18 (−0.04, 0.40)	4	0.07 (−0.13, 0.27)†	0.14 (−0.24, 0.51)
Long-term Follow-up (≥ 6 weeks)						
Quantity	8	**0.20 (0.08, 0.31)**	**0.20 (0.08, 0.31)**	4	0.02 (−0.18, 0.22)	0.02 (−0.18, 0.22)
Quantity, specific intervals/drinking days	1	--	--	5	0.03 (−0.12, 0.18)	0.03 (−0.12, 0.18)
Maximum quantity	4	0.09 (−0.06, 0.24)	0.08 (−0.07, 0.25)	3	0.14 (−0.40, 0.12)	0.14 (−0.40, 0.12)
Frequency of heavy drinking	1			8	−0.11 (−0.22, 0.01)†	−0.07 (−0.27, 0.13)
Frequency of drinking days	3	**0.28 (0.10, 0.46)**	**0.28 (0.10, 0.46)**	4	0.03 (−0.16, 0.22)	0.04 (−0.18, 0.26)
Problems	5	0.14 (−0.01, 0.28)	0.14 (−0.01, 0.28)	6	**0.17 (0.05, 0.30)**	**0.16 (0.03, 0.30)**

*Non-relevant controls refer to wait-list/assessment only (94% at short-term, 100% at long-term) and irrelevant content unmatched for time (6% at short-term). Relevant controls refer to comparisons with alcohol-related content matched (68% at short-term, 70% at long-term) or unmatched (30% at short-term, 11% at long-term) for time and alcohol-related education (2% at short-term, 20% at long-term). CDIs, computer-delivered interventions. *k*, number of interventions. d+, weighted standardized mean difference. CI, confidence interval.

†Heterogeneous distribution, *P*s <.05.

Table 3

Efficacy of interventions and controls from pre- to post-test by follow-up interval and control type*

	Interventions		Non-Relevant Controls		Relevant Controls	
Outcome	***k***	***d*+ (95% CI)**	***k***	***d*+ (95% CI)**	***k***	***d*+ (95% CI)**
Short-term Follow-up (≤5 weeks)						
Quantity	14	**0.17 (0.09, 0.26)**	4	0.02 (−0.14, 0.19)†	10	**0.26 (0.16, 0.35)**
Quantity, specific intervals/drinking days	17	**0.32 (0.23, 0.42)**	3	**0.22 (0.01, 0.44)***	9	**0.26 (0.14, 0.38)**
Maximum quantity	7	**0.26 (0.15, 0.37)**	1	--	6	**0.21 (0.10, 0.33)**
Frequency of heavy drinking	12	**0.14 (0.04, 0.16)**	5	**−0.17 (−0.28, −0.05)†**	6	**0.28 (0.16, 0.39)†**
Frequency of drinking days	16	**0.17 (0.07, 0.27)**	2	0.12 (−0.17, 0.42)*	9	**0.19 (0.07, 0.32)**
Problems	9	**0.14 (0.04, 0.23)**	4	**−0.24 (0.07, −0.38)†**	4	**0.34 (0.17, 0.50)†**
Long-term Follow-up (≥ 6 weeks)						
Quantity	8	**0.32 (0.21, 0.42)**	3	0.05 (−0.09, 0.19)†	5	**0.33 (0.19, 0.46)**
Quantity, specific intervals/drinking days	6	0.08 (−0.02, 0.18)	1	--	4	**0.27 (0.12, 0.42)†**
Maximum quantity	6	**0.22 (0.11, 0.33)**	3	0.01 (−0.12, 0.13)†	3	**0.69 (0.46, 0.91)†**
Frequency of heavy drinking	5	**0.26 (0.13, 0.39)**	0	--	4	**0.27 (0.13, 0.42)**
Frequency of drinking days	5	0.09 (−0.02, 0.21)	1	--	3	**0.29 (0.12, 0.46)†**
Problems	5	0.10 (−0.01, 0.20)	3	−0.03 (−0.15, 0.10)*	2	0.09 (−0.09, 0.28)

*Non-relevant controls refer to wait-list/assessment only. Relevant controls refer to comparisons with alcohol-related content matched (31% at short-term and 100% at long-term) or unmatched (69% at short-term) for time. Weighted mean effect sizes, *d*+, for which the 95% CI does not include a zero are significant. Effect sizes are based on fixed-effects assumptions; for most outcomes, parallel results were found using random-effects assumptions with the exception of quantity at specific intervals/drinking days for the intervention group, maximum quantity of alcohol consumption, and frequency of heavy drinking, all at long-term follow-up. CDIs, computer-delivered interventions. *k*, number of interventions. *d*+, weighted standardized mean difference. CI, confidence interval. Boldface text highlights significant values.

†Comparisons between intervention and control type (between-groups *Q*) is statistically significant at $P < .05$.

APPENDIX 1

Descriptive features of the 35 computer-delivered alcohol intervention studies included in the meta-analysis*

						Intervention Details					
Study	**N**	**F**	**W**	**University**	**Control**	**Delivery**	**Location**	**Sessions**	**Dose†**	**Program**	**Quality Rating‡**
Allison [47]	148	43%	91%	US-NE, M public	RM	CD-ROM (G)	Onsite	1	120	A101	3
Barnett et al. [48]	215	51%	76%	US-NE, L private	RM	CD-ROM	Onsite	2/1	70/45	A101	13
Bersamin et al. [49]											
Drinkers	139	52%	30%	US-SW, L public	WL/NT	Internet	Offsite	2.6	93.6	Other	7
Non-Drinkers	231										
Butler and Correia [50]	84	65%	92%	US-SE, L public	WL/NT	Internet	Onsite	1	11.1	Other	7
Carey et al.[43]	192	46%	91%	US-NE, L private	RNM	CD-ROM	Onsite	1	60	A101	11
Chiauzzi et al. [51]	212	54%	73%	US-NE, multiple	RM	Internet	Offsite	4	80	MSB:A	10
Dimeff & McNeely [52]	33	63%	73%	US-NW, L public	WL/NT	CD-ROM	Onsite	2	19	Other	11
Donohue et al. [53]	104	56%	63%	US-SW, L public	RNM	CD-ROM	Onsite	1	45	A101	11
Doumas et al. [54]	67	28%	86%	US-NW, L public	RNM	Internet	Onsite	1	15	Other	10
Doumas & Anderson [55]	52	41%	79%	US-NW, L public	WL/NT	Internet	Onsite	1	15	e-Chug	6
Doumas & Haustveit [56]	52	42%	54%	US-NW, L public	RM	Internet	Onsite	1	15	Other	6
Fishburne [57]	213	63%	NR	US-SE, L public	RM	Intranet	Onsite	1/1	35/35	Other	10
Hunt [58]						Low-level: Ppt slideshow			12		
	158	0	64%	US, L public	IM	High-level: Macromedia	Onsite	1	20	Other	9
Kypri et al.[59]	360	52%	NR	New Zealand	EDUC	Internet	Onsite	1/3	6/18	Other	12
Kypri et al.[60]	94	50%	91%	New Zealand	EDUC	Intranet	Onsite	1	7.8	Other	12
Kypri & McAnally [61]	126	51%	75%	New Zealand	WL/NT	Internet	Onsite	1	11.8	Other	10
Lao-Barraco & Dunn [62]	103	57%	76%	US-SE, L public	IRM	CD-ROM	Onsite	1	105	A101	10
Leffingwell et al.[63]	70	22%	90%	US-SW, L public	WL/NT	CD-ROM	Onsite	1	35	Other	12
Lewis et al.[39]	230	52%	100%	US-MW, L public	WL/NT	Intranet	Onsite	1	5	Other	11
Lewis & Neighbors [64]	165	55%	97%	US-NW, L public	WL/NT	Intranet	Onsite	1	1.5	Other	11
Michael [65]	676	45%	52%	US	NR	CD-ROM	Onsite	1	120	A101	5
Mignogna [66]											
Study 1	28	58%	81%	US-SW, L public	EDUC	Multiple	Both	28	57	Other	10
Study 2	19	16%	94%	US-SW, L public	WL/NT	Multiple	Both	37	106	Other	11

						Intervention Details					
Study	**N**	**F**	**W**	**University**	**Control**	**Delivery**	**Location**	**Sessions**	**Dose†**	**Program**	**Quality Rating‡**
Miller [67]	445	63%	70%	US-NW, L public	WL/NT	CD-ROM (G)	Onsite	2	180	A101	13
Moore et al.[68]	106	58%	70%	US-SE, L public	RM	Internet & Email	Offsite	4	40	Other	9
Neighbors et al.[40]	207	59%	80%	US-NW, L public	WL/NT	Intranet	Onsite	1	1	Other	12
Neighbors et al.[69]	185	56%	98%	US-MW, L public	WL/NT	Intranet	Onsite	1	1.5	Other	12
Neighbors et al.[70]	282	58%	67%	US-NW, L public	WL/NT	Internet	Offsite	2	20	Other	11
Saitz et al.[71]	235	55%	81%	US-NE, L private	RNM	Internet	Offsite	1	20	Other	8
Steiner et al.[72]	159	61%	NR	US-SW, L public	WL/NT	Internet	Offsite	1	25	e-Chug	9
Wall [21]	23,127	53%	82%	US & Canada	WL/NT	Internet	Unknown	1	150	AEdu	6
Walters et al. [41]	82	48%	73%	US-SW, L public	WL/NT	Internet	Unknown	1	25	e-Chug	10
Weitzel et al.[73]	40	55%	77%	US-SE, L private	WL/NT	PED	Offsite	10.93	26	Other	8
Wyrick et al.[74]	65	77%	55%	US-SE, L public	NR	Internet	Both	3	60	Other	5

*N, number of participants. F, proportion female. W, proportion White. US = United States. NE = Northeast. SE = Southeast. MW = Midwest. SW = Southwest. S = Small. M = Medium. L = Large. WL/NT, wait-list/no treatment control. PED, portable electronic device. G, group delivery. A101, Alcohol 101 (Plus). MSB:A, My Student Body: Alcohol. e-Chug, electronic check-up to go. AEdu, Alcohol Edu. NR, none/not reported.

†Estimated number of minutes of intervention content excluding measurement.

‡Methodological quality rating score out of a possible 17 points.

APPENDIX 2

Description of studies, samples, intervention, and control conditions.

Study characteristics (k =35)	
Year of publication (k = 27)	
Mdn	2005
Range	2000 – 2008
Year of data collection	
Mdn	2004
Range	1994–2007
Year of program development	
Mdn	2002
Range	1993–2006
Published	60%
* Financial Support	
Public	57%
Private	17%
None/NR	26%
Region of Sample	
US Northeast	14%
US Southeast	17%
US Midwest	6%
US Southwest	23%
US Northwest	23%
Non-US region	9%
Multiple regions	9%
* Type of institution (k = 33)	
Public university	85%
Private university	12%
Multiple institutions	3%
* Size of institution (k = 33)	
<6,000 students	3%
6,000 – 10,000 students	3%
>10,000 students	91%
Multiple	3%
Targeted intervention (% yes)	91%
Target group (k = 32)	
Heavy drinkers	28%
College freshman	23%
High-risk drinkers	14%
Current drinkers	13%
Alcohol violators	13%
Upperclass students	3%

Students turning 21	3%
Athlete	2%
Males	2%
Methodological quality score (17 points total)	
Mean (SD)	9.37 (2.52)
Mdn	10
Range	3 – 13
Research design and implementation (*k* = 35)	
Recruitment method	
Volunteered	53%
Recruited	33%
Mandated	14%
Random Assignment	
Randomized individuals	74%
Randomized groups	17%
Nonequivalent control group	9%
Pretest post-test design (% yes)	100%
No. post-intervention assessments	
Mean (SD)	1.63 (0.73)
Mdn	1
Range	1 – 3
First post-intervention assessment	
Mean weeks (SD)	5.06 (5.63)
Mdn	4.33
Range	0 – 26
Sample Characteristics (*k* = 35)	
Sample Size (N)	
Total	28,621
Mean (SD)	817.74(3884)
Mdn	148
Year in school (mean %)	
Freshman	68%
Sophomore	15%
Junior	12%
Senior	5%
Graduate	1%
Age in years (*k* = 31)	
Mean (SD)	19.71 (1.09)
Range	18 – 22
% women	
Mean (SD)	0.50 (0.15)
% Greek members (*k* = 9)	

Mean (SD)	0.23 (0.15)
% White	
Mean (SD)	0.75 (0.17)
% Black	
Mean (SD)	0.10 (0.12)
% Asian	
Mean (SD)	0.13 (0.12)
% Hispanic	
Mean (SD)	0.08 (0.05)
Intervention Characteristics (*k* = 55)	
No. of intervention conditions	
Mean (SD)	1.36 (0.48)
Mdn (Range)	1 (1 – 2)
Level of intervention	
Self-directed	86%
Group delivered	7%
Computer and group session(s)	5%
Computer and in-person session	2%
Self-directed computer/web (*k* = 48)	
No. of sessions (Mdn)	1
No. of minutes (Mdn)	20
Group-delivered computer/web (*k* = 4)	
No. of sessions (Mdn)	1
No. of minutes (Mdn)	120
Computer/web and group session (*k* = 4)	
No. of computer sessions (Mdn)	31.5
No. of computer minutes (Mdn)	1
No. of group sessions (Mdn)	1
No. of group minutes (Mdn)	30
Computer/web and in-person session (*k* = 1)	
No. of computer sessions (Mdn)	1
No. of computer minutes (Mdn)	15
No. of in-person sessions (Mdn)	1
No. of in-person minutes (Mdn)	4
Interactive intervention (% yes)	93%
Intervention content tailored	
Individual	89%

Group	2%
None/NR	9%
* Intervention Components	
Feedback on consumption	86%
Alcohol education	77%
Normative comparisons, generic	77%
Tailored materials	61%
Modification strategies	43%
Challenges/expectancies	39%
Feedback on problems	36%
Focus on high-risk situations	34%
Feedback on risk factors	30%
Normative comparisons, matching	25%
General alcohol-related materials	20%
Writing and/or journaling	16%
Goal-setting	13%
Values clarification	7%
Decisional balance	2%
Delivery mechanism	
Internet	38%
Intranet	30%
CD-ROM/Interactive DVD	25%
Multiple delivery modes	5%
Portable electronic device	2%
Delivery setting	
On-site	72%
Off-site	24%
Unknown	4%
Type of commercially available program used	
None	59%
Alcohol 101 (Plus)	20%
College Alc	7%
Electronic Check-Up to Go	5%
Check Your Drinking	4%
My Student Body: Alcohol	4%
Alcohol Edu	2%
Computer program includes avatar (%)	23%
Comparison Characteristics (k = 54)	
Type of control/comparison	
Wait-list/no treatment	43%
Relevant content, time-matched	31%

Relevant content, not matched	13%
Education-only	8%
Irrelevant content, time-matched	6%
Active comparison conditions (*k* = 31)	
No. of sessions (Mdn)	1
Total dose in minutes (Mdn)	35
Delivery mechanism	
Intranet	33%
Face-to-face	32%
Internet	23%
Print materials	13%
Provided alcohol-related materials (% yes)	28%

Note. *k* = number of interventions; NR, not reported.

* Multiple categories were possible