A meta-analysis of effectiveness of E-Interventions to reduce alcohol consumption in college and university students

Journal:	*Journal of American College Health*
Manuscript ID	JACH-2017-08-0285.R1
Manuscript Type:	Major Article
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Abstract:	Objective: To evaluate the effectiveness and moderators of E-Interventions versus assessment only (AO) controls in the reduction of alcoholic drinks per week (DPW) in university students. Study design and methods: Studies were included if they were: an RCT, assessed the effectiveness of E-Interventions at reducing DPW, and employed university/college students. 23 studies (N = 7,614) were included and quality was assessed using the JADAD scale. Results: Weighted mean effect sizes were calculated using random-effects models. These showed a small, significant effect of E-Interventions at reducing the number of alcoholic DPW. Moderator analysis found a significant advantage for web-based personalised feedback interventions compared to other E-Interventions. Conclusions: E-Interventions show a small, significant effect at reducing mean alcoholic DPW. Personalised feedback E-Interventions showed the strongest effect.

TITLE PAGE

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Abstract

Objective: To evaluate the effectiveness and moderators of E-Interventions versus assessment only (AO) controls in the reduction of alcoholic drinks per week (DWP) in university students.

Study design and methods: Cochrane library, CINAEL, ERIC, MEDLINE, PsycINFO, PubMed, and Web of Science were searched up to June 2017. Studies were included if they were: an RCT, assessed the effectiveness of E-Interventions at reducing DWP, and employed university/college students. 23 studies (N = 7,614) were included and quality was assessed using the JADAD scale.

Results: Weighted mean effect sizes were calculated using random-effects models. These showed a small, significant effect of E-Interventions at reducing the number of alcoholic DWP. Moderator analysis found a significant advantage for web-based personalised feedback interventions compared to other E-Interventions.

Conclusions: E-Interventions show a small, significant effect at reducing mean alcoholic DPW. Personalised feedback E-Interventions showed the strongest effect.

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From neighbours sharing homebrewed cider to internationally recognisable events such as Oktoberfest[1] drinking is part of global social customs. However, with the consumption of alcohol comes a risk of adverse health and social consequences[2]. A period synonymous with drinking is college/university years (students aged 18 and above) [3], with alcohol use increasing significantly following the transition from secondary school to college/university in American and other nationalities of students[4,5]. Furthermore, college/university students misuse alcohol to a greater degree than their non-student peers, with approximately 45% of students reporting a recent episode of heavy alcohol consumption on a monthly basis[6]; a heavy drinking episode being classified as drinking five or more alcoholic drinks for men or four or more drinks for women in a two-hour period[7].

Both alcohol use in general, and heavy episodic drinking in particular, are associated with significant health and other risks[8,9]. For example, 47% of students who engaged in heavy episodic drinking experienced five or more drink-related problems (e.g. injuries and engagement in unplanned sexual activities[9]). However, heavy episodic drinking students frequently do not see this behaviour as problematic, and rarely pursue help for an alcohol problem[9]. Moreover, alcohol misuse in college/university student populations is an international issue[10]. Therefore, there has been a drive for research to focus on developing and improving a range of interventions that target problem drinking with students[5], including, in recent years, a substantial increase in interest in E-interventions[11].

The term E-interventions refers to any intervention delivered, carried out or received via electronic means, ranging for text messages to participants accessing a website with the intervention material on it. E-interventions can be advantageous as they tend to be a cheaper and less time consuming alternative to the traditional model of face-to-face support, and can be delivered across an array of personal devices, enabling students to approach the intervention at their own pace, whilst sustaining privacy[12]. Their accessibility, greater reach

and low cost are appealing for student populations[13], and they could be especially useful for students on waiting lists for face-to-face support[14,15], since waiting lists are typically long[16] as resources are often limited[17].

However, E-Interventions may not be without their limitations. Some suggest that E-Interventions prevent or restrict the development of the therapeutic alliance between therapist and patient[18], and as E-Interventions occur in private spaces, difficulties may also arise in relation to motivation and compliance[19], potentially leading to increasing attrition or non-compliance[19]. In light of the potential advantages and limitations of E-interventions for alcohol misuse, a number of meta-analyses have examined their effectiveness in student populations[20–23].

Nine meta-analyses have examined the efficacy of E-Interventions at reducing alcohol consumption in the general population [5,13,20,24–29]. In eight of the nine meta-analyses a small significant effect was found in favour of E-interventions in the short-term (<4 months). However, no effect has been shown past 12 months, and it is unclear whether these results generalize to a college/university population, who are potentially more 'at risk' through the prevalence and acceptability of binge drinking within their cultural context.

To date there have been six meta-analyses and narrative reviews that have examined both face-to-face and E-Interventions that target hazardous drinking in the student population [23,30–34]. These have found strong support for brief motivational interventions combined with personalised feedback, with intervention effects lasting up to 6 months. However, this raises the question of whether these interventions are still effective with students who are not yet drinking to a hazardous level. Furthermore, the fact that face-to-face and E-Interventions were combined in these meta-analyses and reviews, somewhat limits our ability to draw conclusions about the efficacy of the latter.

Three meta-analyses have examined E-Interventions on their own in student populations[21,35,36], including first year college students and mandated college students, in other words those who had broken campus policy on drinking. The most recent meta-analysis using a general student population undertaking an E-Intervention was published in 2012[36].Their results showed E-Interventions were effective at reducing drinking (d_+s=0.07 – 0.14). However, this meta-analysis only included studies publication up until 2011. Since then there have been 13 additional RCTs evaluating the efficacy of E-Interventions at reducing alcohol consumption in students. Some of these new studies have trialled new forms of E-Interventions, thought to be better suited for this population[33]. Furthermore, given the rapid changes in technology that students have access to, there is now a wider variety of means of offering E-interventions to students[37]. Therefore, a new meta-analysis of the efficacy of E-Interventions for student alcohol misuse is timely.

To this end, the current meta-analysis aimed to: (i) provide an up to date assessment of the extent to which E-Interventions reduce the number of alcoholic drinks a student consumes per week relative to assessment only controls; and (ii) carry out a moderator analyses examining whether their effectiveness has increased over time, whether E-Interventions are better suited for students who have already been classified as being 'at risk' drinkers, and whether web-based personalised feedback remains the most effective form of E-Intervention.

Method

Search strategy and study selection

Studies were retrieved from the following electronic databases from the inception of the database to June 2017: Cochrane library, CINAEL, ERIC, MEDLINE, PsycINFO, PubMed,

and Web of Science. The search string was: (alcohol OR drink*) AND (college OR university OR undergraduate* OR student) AND (RCT OR "randomised controlled trial" OR "randomised controled trial" OR "randomized controlled trial" OR "randomized controlled trial") AND (computer OR internet OR intranet OR DVD OR email OR text OR app* OR *phone OR SMS OR telehealth OR tele-health OR eHealth OR e-health OR mhealth OR m-health OR smart*). After the studies were retrieved, a screening process was conducted following the PRISMA protocol. The studies were included if: (i) they were a randomised controlled trial (RCT); (ii) the intervention was an E-intervention, in that the intervention was delivered via a technological device,; (iii) the participant group was solely composed of those entering or current college/university students, this took into account that the term 'college' in the UK is the equivalent to American senior high schools (students between 16-18) and therefore studies looking at this age group were excluded; (iv) the study was published in English in a peer reviewed journal, (v) the necessary data could be accessed from either the paper or was provided by the authors, and (vi) the study investigated the effect of the chosen intervention on the number of drinks the student consumed in a week.

To see if any further relevant studies could be found, the first author hand searched the reference sections of the selected papers. In addition, the last four years' worth of issues of the four most frequent journals among the selected studies, namely *Addictive Behaviour, Psychology of Addictive Behaviour, Journal of Consulting and Clinical Psychology and BMC Public Health*, were hand searched for missing articles.

Figure 1 illustrates the search and screening process in a PRISMA diagram. The initial search produced 1,669 studies and 85 were identified by hand-searching. Twenty-three of these met criteria for inclusion in the meta-analysis[5,38–59].

Study quality

The quality of the studies was assessed using the JADAD scale, which produces a rating of zero to five, with five indicating the highest quality [60]. All of the papers were rated independently by two raters. The ratings were identical for 18 out of the 23 papers. For five studies, the raters disagreed by one point and for one study by two points. After a discussion between the raters, an agreement was reached on the score for all papers (see Table 1).

Data analysis

The between group, post-intervention means, sample sizes and standard deviations for the measure of drinks per week were extracted and entered into Review Manager (Revman) version 5.3. The following formula was used by Revman to calculate post-intervention between group effect sizes:

$$SMD_i = \frac{m_{1i} - m_{2i}}{S_i}\left(1 - \frac{3}{4N_i - 9}\right)$$

Where,

$$S_i = \sqrt{\frac{(n_{1i} - 1)sd_{1i}^2 + (n_{2i} - 1)sd_{2i}^2}{N_i - 2}}$$

'Drinks per weeks'[61] was selected to provide a standardised measurement across all of the studies and as it can be regarded as a broad way of determining the effectiveness of an intervention. For all studies, the assessment only control condition was selected as the comparator, as every study included such a control group, but few included an active control condition. If the study included multiple intervention conditions, the condition that most closely fitted the description of an E-intervention was selected. If multiple versions of that intervention were being used (e.g. a basic format vs. more elaborate E-intervention), then the more sophisticated intervention was selected. Due to the range of different interventions used

in the analysis, a random effects model was employed to account for differences between the interventions.

A forest plot of post-interventions between-group effect sizes was produced using RevMan. Comprehensive meta-analysis (CMA) software (Professional version) was employed to run a meta-regression between the quality ratings and effect sizes. To explore publication bias, a funnel plot was produced using RevMan, and Rosenthal's failsafe N [62] was calculated using the Excel spread sheet produced by De Coster and Iselin (available from http://www.stathelp.com).

Results

Study outcomes

While many of the studies tested a variety of factors, the primary outcome for our analysis was drinks per week (DPW). Studies measured this in a variety of ways, including asking participants to report their alcohol consumption over the course of a day, week or month, which were all transformed by the studies to provide a weekly consumption. There was also variation in how these data were captured. Some studies asked participants to upload information each day on to an app or website, while others asked the participants to recall their consumption at the end of the week or month. While research has shown this to be an accurate method of collecting data when participants had consumed a low to moderate amount of alcohol, participants often under-estimate their consumption after a heavy drinking episode[63].

Study Characteristics

The characteristics of included studies are presented in Table 1. The study publication dates ranged across 13 years from 2004 to 2017. The number of participants included in the meta-analysis was N=7,614 (E-intervention n=3,617, assessment only n=3,997). The majority

of studies came from the USA (k=16), with the second most common setting being the UK (k=3). The four remaining papers came from Canada, Sweden and the Netherlands respectively.

The majority of participants were recruited by opportunistic sampling (*k*=18), using either students who were about to start college/university or current college/university level students. 1,011 of the 7,614 participants within the sample were college/university students who had either been mandated by their college/university for breaking campus alcohol policies or through the initial screen had been identified as at risk/heavy drinking students.

Interventions used

The most common E-intervention was Web-based personalised feedback (k=17), with phone-based interventions being the second most common (k=2), and education-based interventions and theory based interventions each being employed in only one study. These interventions are now described in more detail.

Web-based personalised feedback

Web-based personalised feedback interventions seek to provide participants with feedback on the amount of alcohol they have been drinking, their average blood alcohol concentration (aBAC), the amount of calories consumed, and their level of consumption compared to the recommended guidelines set by the country they are in. The feedback is personalised by the participant submitting their own information to the intervention, which then provides the participant with feedback depending on their consumption.

Education based

Education based interventions seek to educate the participants about possible risks or harm they could face due to their drinking. This can range from the personal harm they could experience, to the damage drinking related behaviour is having on the surrounding area they live in and the community. Personal harm could be in the form of the damage excessive alcohol can have on their body and the risks it can have on mental health.

Phone based

Phone based interventions refer to the means by which the intervention can be delivered, as personalised feedback, education based interventions and brief motivational interventions can be offered via phone. Most phone based interventions work by sending the participant the outcome of their personalised feedback and/or by sending them motivational messages or facts about drinking, to help keep the participant on track with the intervention or to help shift the participant's behaviour.

Study quality

The study quality scores are presented in Table 1. Half of the studies achieved a JADAD score of 3 out of 5, and the remainder had lower scores. One of the most common reason for dropping two points was the failure to double-blind, which can be challenging in the context of interventions of this nature. No significant association was found between the studies' effects size and the JADAD scores, ($Z=.37$, $p=.71$), suggesting that study quality did not affect the sizes of the outcomes obtained.

Publication bias

A funnel plot was created to test for publication bias (Figure 2). As this showed an asymmetry, there may be some publication bias in the literature. However, a Rosenthal's Fail

Safe N showed that an additional 313 studies showing no intervention effect would be needed to reduce the overall effect size to non-significance, suggesting that the findings are robust.

Main analysis

The test for heterogeneity in effect-sizes was not statistically significant ($\chi^2(22)$= 29.25, p = 0.14, I^2 = 25%). This supports the inclusion of this group of studies in a meta-analysis, and the combining of their findings into one pooled effect-size. The test for the overall effect found a small, but highly significant, effect (Z = 4.80, p< 0.00001, SMD = -0.15, CI 95% [-0.21, -0.09]). Thus, E-Interventions are effective at reducing the number of alcoholic drinks students consume per week compared to assessment only controls.

Moderator analysis

Three moderator analyses were conducted.

At risk vs. any drinkers

Studies were included in the 'at risk' category if they had given their participants a pre-intervention test to assess their drinking behaviour and had found the drinking to be at harmful levels. The test for the overall effect for the 'at risk' students was not significant (Z = 1.88, p=0.06, SMD = -0.20, CI 95% [-0.40, 0.01]). The test for the overall effect of the 'any drinkers' showed a significant, small effect (Z = 5.29, p< .00001, SMD = -0.13, CI 95% [-0.18, -0.08]). However, the test for sub-group differences was not significant, ($\chi^2(1)$ = 0.35, p = 0.55).

Publication date

A comparison was run between studies that were published before 2012 and those that were published subsequently. This date was selected as the most recent meta-analysis in this area had included studies up to 2011. For the earlier studies, there was a significant effect in the small to medium range (Z = 3.13, p=0.002 .0001, SMD = -0.24, CI 95% [-0.39, -0.09]),

and for the later studies, there was also a significant, small effect (Z = 3.67, p=0.0002, SMD = -0.1, CI 95% [-0.16, -0.05]). The difference between these sub-groups was marginally significant, but did not reach full significance ($\chi^2(1) = 2.77$, p = 0.1). Thus there was tentative evidence that more recent studies may have smaller effect sizes than pre-2012 ones. However, when year of publication was used as a continuous predictor in a meta-regression it was non-significant Z=.94, p= .35.

Web-based personalised feedback vs. other interventions

A comparison was run between studies that were conducted using a web-based personalised feedback and those that used other types of interventions. The studies were selected for the web-based personalised feedback group if the intervention had been described using the term 'personalised feedback' and had been delivered using email, website or web-based technology. For the web-based personalised feedback interventions, there was a significant effect in the small to medium range (Z = 4.69, p<0.00001, SMD = -0.19, CI95% [-0.27, -0.11]). For the other interventions, there was no significant effect (Z = 1.84, p=0.07, SMD = -0.07, CI95% [-0.14, 0.00]). Overall, there was a significant difference found in the effect size between these two sub groups, ($\chi^2(1) = 5.30$, p = 0.02). The forest plot associated with this moderation analysis is shown in Figure 3.

Follow up

Some studies collected additional outcome data at follow-up time point(s), after the post-intervention time-point. Therefore, an analysis was conducted, comparing drink per week for E-Interventions with assessment only controls at follow-up. In cases where a study had more the one follow-up time point, the longest follow-up for which data were available was included. This resulted in six studies being included, with their included follow-ups ranging from 6 to 12 months' post-intervention. The forest plot can be seen in Figure 4. No

significant difference between the groups was found (Z = 1.31, p=0.19, SMD = -0.05, CI 95% [-0.12, 0.02]).

Discussion

This meta-analysis examined the effectiveness of E-Interventions compared to assessment only controls at reducing the number of alcoholic drinks college/university students drank per week. 56.52% (i.e. *k* =13) of the included studies were published since the last meta-analysis that specifically examined such E-Interventions in students, confirming the need for a new meta-analysis. Furthermore, the low level of heterogeneity between the included studies makes it credible to argue that they were testing similar enough interventions to be combined in a meta-analysis.

The results showed a small, significant reduction in drink per week following E-Interventions relative to assessment only controls. This overall finding is consistent with previous meta-analyses [21,23,33,34], and adds to the growing pool of evidence that E-Interventions can support students in reducing their daily drinking. In addition, web-based personalised feedback was found to be the most effective of the E-Interventions, while there was not good evidence of a difference in efficacy of E-Interventions between 'at risk' and 'any drinkers'.

However, the beneficial effects of E-Interventions disappeared after 6 to 12 months, since the intervention and control conditions no longer significantly differed in the analysis of the follow-up data. Therefore, future research could helpfully focus on maintaining treatment effects over a longer time period. In addition, the most surprising finding was the tentative evidence towards more recent studies showing smaller effects compared to pre-2012 trials. This result does not appear to be driven by any changes in study quality that may have occurred over time, since the latter was not associated with effect size. However, the apparent

decline in effect size over time should be treated with some caution, given that it was only marginally significant. If this trend is found to be robust in future meta-analyses conducted after further RCT have been completed, then it would be a cause for concern. By way of comparison, it is interesting to note that a decrease in the efficacy of interventions over time has been found in a meta-regression of interventions for depression[64].

Implications and limitations

Based on the current findings, the use of E-Interventions, and in particular web-based personalised feedback, appears warranted for both 'at risk and 'any' student drinkers. However, these interventions may need to be repeated 6 to 12 months after the first 'course' of the intervention has been completed, since their treatment effects do not appear to be maintained at 6 to 12 month follow-up.

The main limitations of this meta-analysis are that: (i) a small number of studies examined interventions other than web-based personalised feedback, limiting the extent to which the efficacy of different types of interventions could be compared; (ii) there was some suggestion of publication bias, which may have led to an over-estimation of the effects of the interventions; (iii) there were too few trials with active control groups to conduct a meta-analysis of E-Interventions versus such controls, which would have been a more stringent test of their efficacy; and (iv) generally participants' self-reported alcohol consumption was relied upon to measure outcomes, the limitations of which have already been described.

A technological advance that appears to have the potential to address this latter limitation is the recent development of wearable technology that can measure blood alcohol levels[65]. Assuming that such technology can demonstrate satisfactory reliability and validity of measurement at an affordable cost-base, it could be used in trials to generate outcome

measurements that would likely have greater validity than self-report. In addition, it would also appear to have the potential to support more efficacious personalised-feedback E-Interventions, since the feedback would be based on a more accurate measurement of participants' alcohol consumption than in the current interventions, which rely on self-report. Therefore, feasibility RCTs evaluating such an approach would seem a helpful next step for the field.

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Table 1 Characteristics of the studies included in the meta-analysis

Footnote. (Target group) UStd = University students, MUStd = Mandated university students, HdUStd = Heavy drinking university students. (Nature of Intervention) Wb-PF = Web-based personalised feedback, Wb-PF+SN = Web-based personalised feedback with social norms, PhD-BMI = Phone-delivered brief motivational intervention, Tb-HBI = theory-based online health behaviour intervention, PhD-BI = Phone delivered brief intervention. Wb-PF+BI = Web-based personalised feedback and brief intervention, Wb-PF+Edu = Web-based personalised feedback and education intervention. FB+ST = Feedback and skills training. PBS = Protective behavioural strategies

Figure 1: Flow of information from collection to inclusion of studies.

Figure 2: A funnel plot of post-intervention effect sizes by standard error.

Figure 3. Forest plot for post-intervention between-group effect sizes for the web-based personalised feedback vs. other interventions.

Figure 4. Forest plot for post intervention overall effect for the available follow up results.

Figure 1: Flow of information from collection to inclusion of studies.

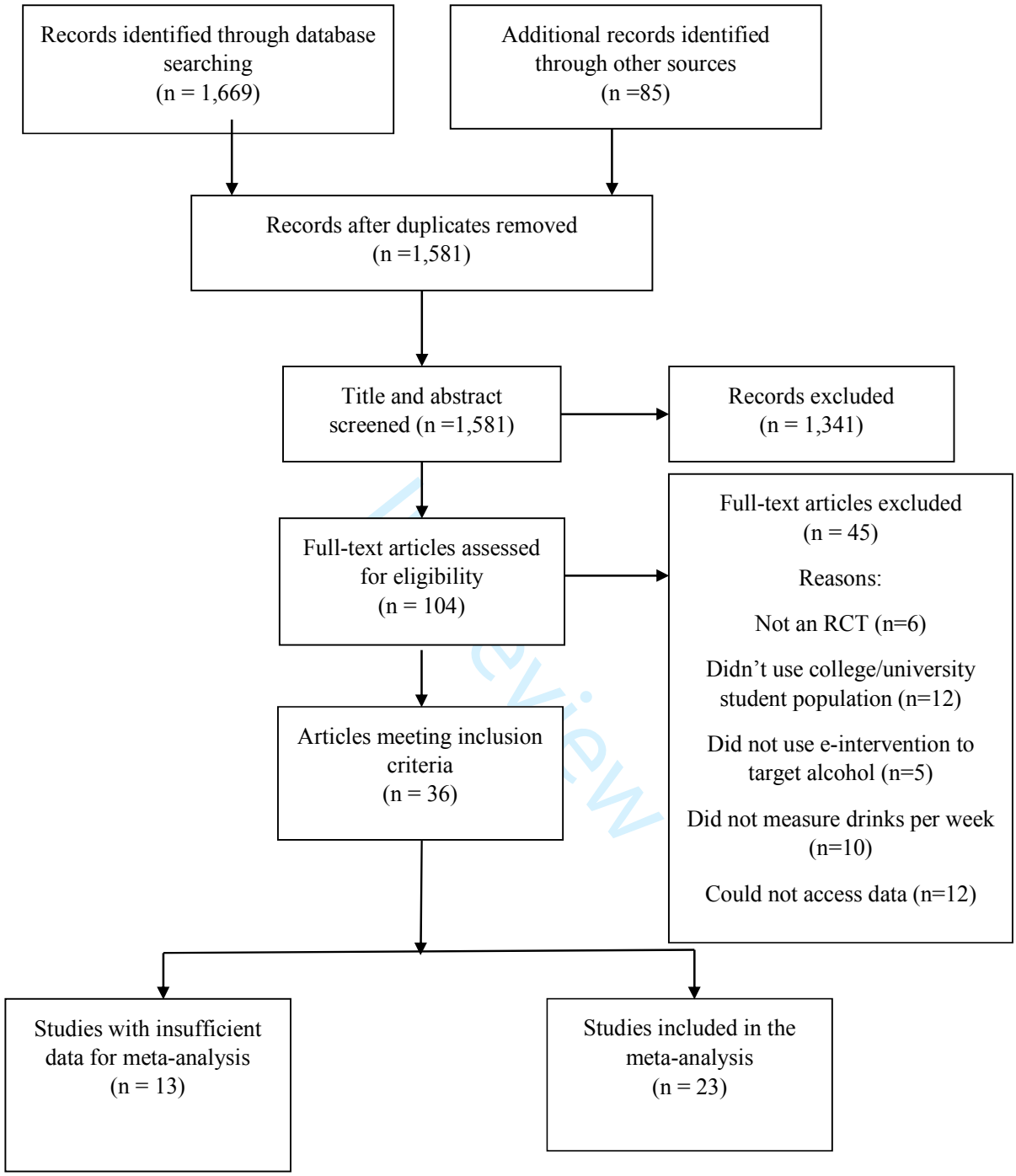

Figure 2: A funnel plot of post-intervention effect sizes by standard error.

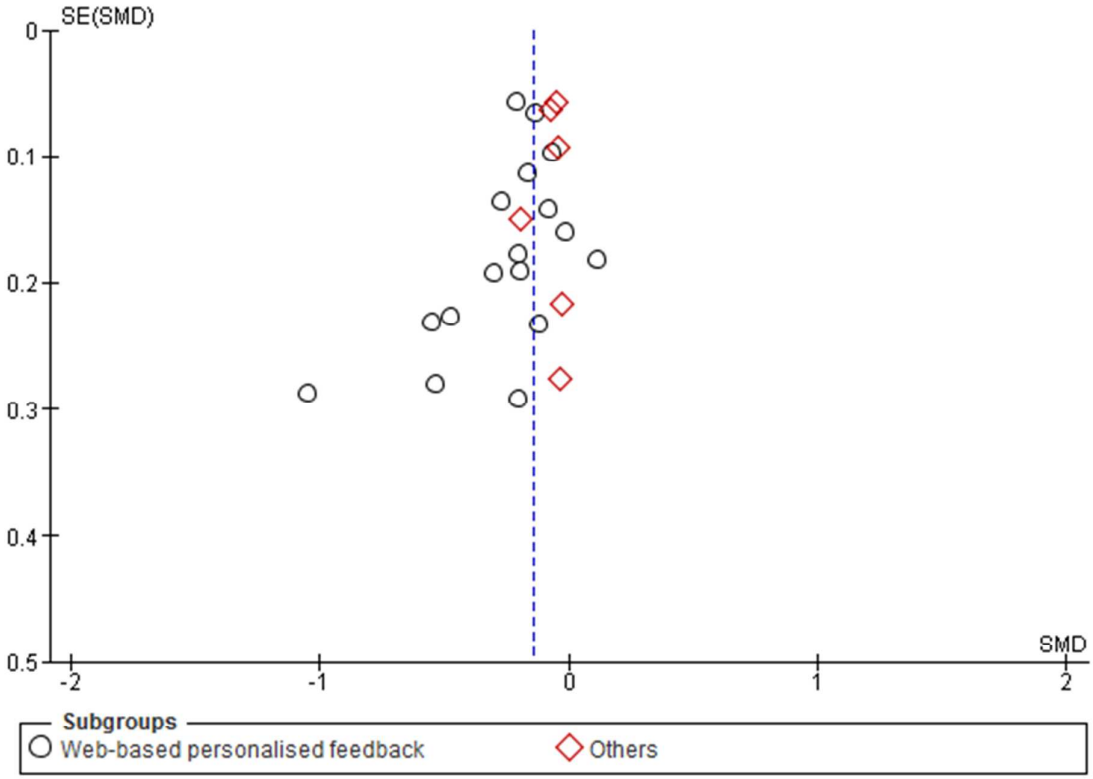

Figure 3. Forest plot for post-intervention between-group effect sizes for the web-based personalised feedback vs. other interventions.

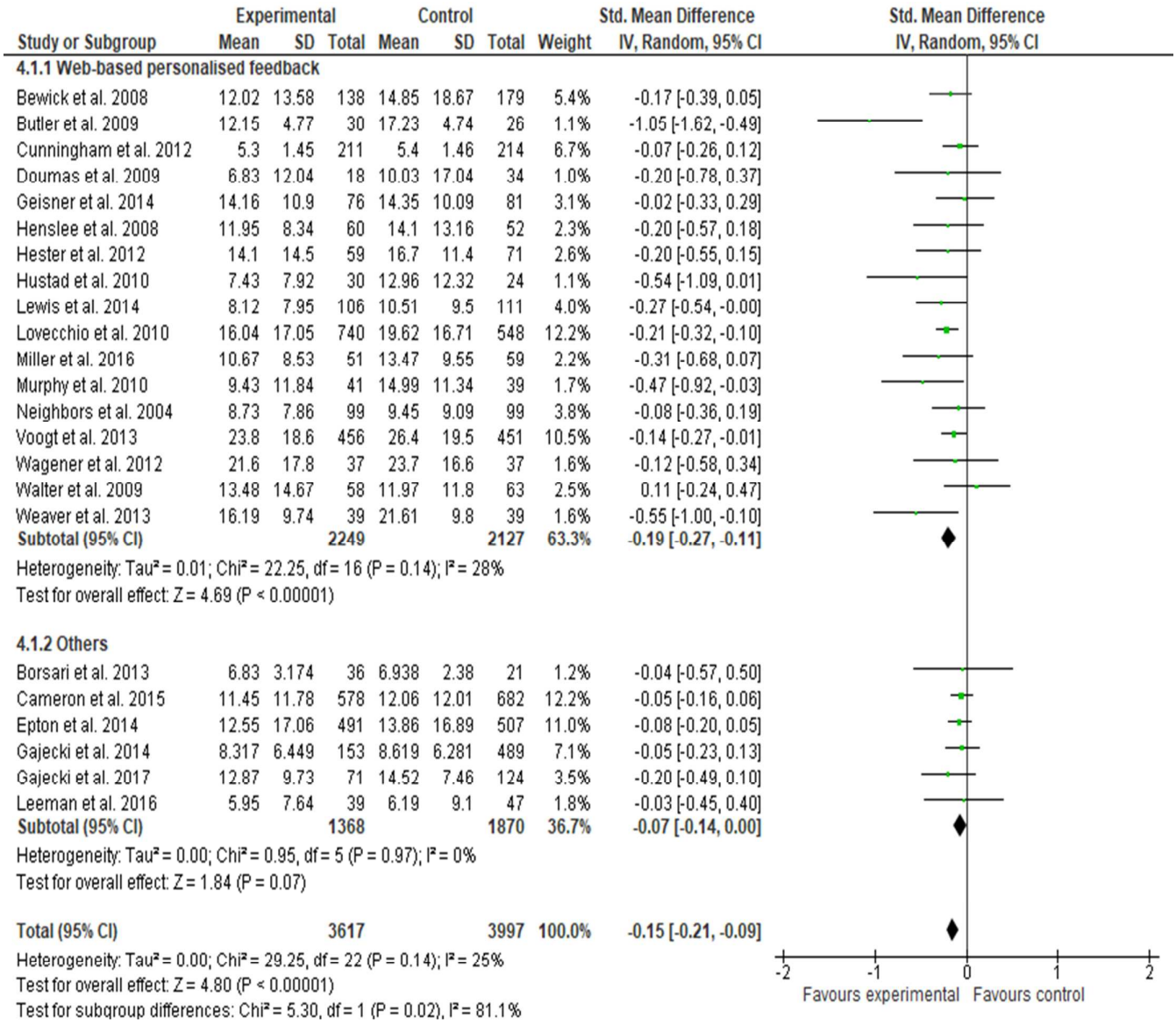

Figure 4. Forest plot for post intervention overall effect for the available follow up results.

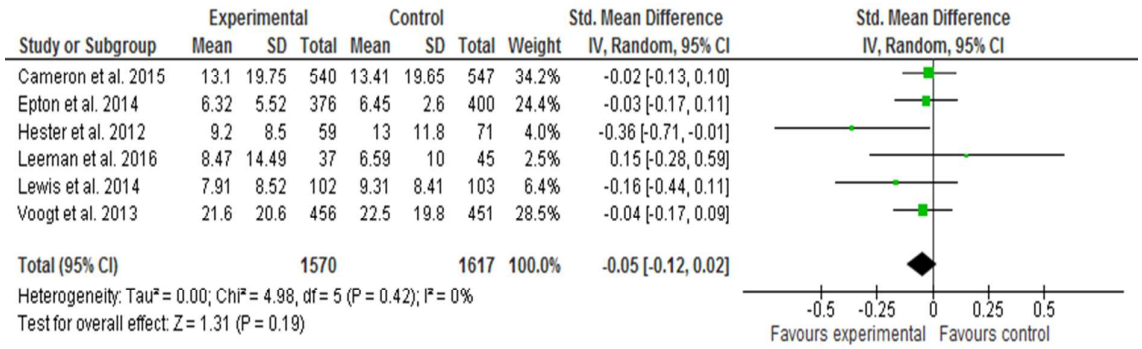

Table 1
Characteristics of the studies included in the meta-analysis

Study (year)	Location	% (Female)	Measurement time-points (months after baseline)	Sample size		Target group	JADAD score (out of 5)	Nature of Intervention
				Intervention (n =)	*Control (n=)*			
Web-based personalised feedback								
Bewick et al. (2008)	UK	69	3	138	179	UStd	2	Wb-PF+SN
Butler et al. (2009)	USA	63	1	30	26	HdUStd	3	Wb-PF
Cunningham et al. (2012)	Canada	47.5	1.5	211	214	HdUStd	2	Wb-PF
Dousmas et al. (2009)	USA	41	3	18	34	UStd	2	Wb-PF
Geisner et al. (2014)	USA	62.4	1	76	81	UStd	1	Wb-PF+BI
Henslee et al. (2012)	USA	63.4	1.25	60	52	UStd	2	Wb-PF
Hester et al. (2012)	USA	45	1 & 12	59	71	UStd	2	Wb-PF
Hustad et al. (2010)	USA	51	1	30	24	UStd	3	Wb-PF
Lewis et al. (2014)	USA	49.8	3 & 6	106	111	UStd	3	Wb-PF
Lovecchio et al. (2010)	USA	54.3	1	740	548	UStd	2	Wb-PF+Edu
Miller et al. (2016)	USA	59	1	51	59	UStd	3	Wb-PF
Murphy et al. (2010)	USA	51	1	41	39	HdUStd	1	Wb-PF
Neighbours et al. (2004)	USA	58.7	3 & 6	99	99	HdUStd	2	Wb-PF
Voogt et al. (2013)	Netherlands	39.7	0.25, 0.5, 1.75 & 4	456	451	UStd	3	Wb-PF+BI
Wagener et al. (2012)	USA	45.4	2.5	37	37	HdUStd	3	Wb-PF
Walter et al. (2009)	USA	64.2	6	58	63	UStd	2	Wb-PF
Weaver et al. (2013)	USA	49.4	1	39	39	UStd	2	Wb-PF
Other								
Borsari et al. (2013)	USA	38.9	3, 6 & 9	36	21	MUStd	1	PhD-BMI
Cameron et al. (2015)	UK	54.9	1 & 6	578	682	UStd	3	Tb-HBI
Epton et al. (2014)	UK	55.2	1 & 6	491	507	UStd	3	Tb-HBI
Gajecki et al. (2014)	Sweden	51.7	1.75	153	489	UStd	3	PhD-BI
Gajecki et al. (2017)	Sweden	68.4	1.5 & 3	71	124	HdUStd	3	FB+ST
Leeman et al. (2016)	USA	62.5	1 & 6	39	47	UStd	2	PBS

Note. (Target group) UStd = University students, MUStd = Mandated university students, HdUStd = Heavy drinking university students. (Nature of Intervention) Wb-PF = Web-based personalised feedback, Wb-PF+SN = Web-based personalised feedback with social norms, PhD-BMI = Phone-delivered brief motivational intervention, Tb-HBI = theory-based online health behaviour intervention, PhD-BI = Phone delivered brief intervention. Wb-PF+BI = Web-based personalised feedback and brief intervention, Wb-PF+Edu = Web-based personalised feedback and education intervention. FB+ST = Feedback and skills training. PBS = Protective behavioural strategies

A meta-analysis of effectiveness of E-interventions to reduce alcohol consumption in college and university students.

Journal of American College Health

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A meta-analysis of effectiveness of E-interventions to reduce alcohol consumption in college and university students.

Abstract

Objective: To evaluate the effectiveness and moderators of E-Interventions versus assessment only (AO) controls in the reduction of alcoholic drinks per week (DWP) in university students.

Study design and methods: Cochrane library, CINAEL, ERIC, MEDLINE, PsycINFO, PubMed, and Web of Science were searched up to June 2017. Studies were included if they were: an RCT, assessed the effectiveness of E-Interventions at reducing DWP, and employed university/college students. 23 studies (N = 7,614) were included and quality was assessed using the JADAD scale.

Results: Weighted mean effect sizes were calculated using random-effects models. These showed a small, significant effect of E-Interventions at reducing the number of alcoholic DWP. Moderator analysis found a significant advantage for web-based personalised feedback interventions compared to other E-Interventions.

Conclusions: E-Interventions show a small, significant effect at reducing mean alcoholic DPW. Personalised feedback E-Interventions showed the strongest effect.

Keywords: meta-analysis, electronic interventions, alcohol, students

From neighbours sharing homebrewed cider to internationally recognisable events such as Oktoberfest[1] drinking is part of global social customs. However, with the consumption of alcohol comes a risk of adverse health and social consequences[2]. A period synonymous with drinking is college/university years (students aged 18 and above) [3], with alcohol use increasing significantly following the transition from secondary school to college/university in American and other nationalities of students[4,5]. Furthermore, college/university students misuse alcohol to a greater degree than their non-student peers, with approximately 45% of students reporting a recent episode of heavy alcohol consumption on a monthly basis[6]; a heavy drinking episode being classified as drinking five or more alcoholic drinks for men or four or more drinks for women in a two-hour period[7].

Both alcohol use in general, and heavy episodic drinking in particular, are associated with significant health and other risks[8,9]. For example, 47% of students who engaged in heavy episodic drinking experienced five or more drink-related problems (e.g. injuries and engagement in unplanned sexual activities[9]). However, heavy episodic drinking students frequently do not see this behaviour as problematic, and rarely pursue help for an alcohol problem[9]. Moreover, alcohol misuse in college/university student populations is an international issue[10]. Therefore, there has been a drive for research to focus on developing and improving a range of interventions that target problem drinking with students[5], including, in recent years, a substantial increase in interest in E-interventions[11].

The term E-interventions refers to any intervention delivered, carried out or received via electronic means, ranging for text messages to participants accessing a website with the intervention material on it. E-interventions can be advantageous as they tend to be a cheaper and less time consuming alternative to the traditional model of face-to-face support, and can be delivered across an array of personal devices, enabling students to approach the intervention at their own pace, whilst sustaining privacy[12]. Their accessibility, greater reach

and low cost are appealing for student populations[13], and they could be especially useful for students on waiting lists for face-to-face support[14,15], since waiting lists are typically long[16] as resources are often limited[17].

However, E-Interventions may not be without their limitations. Some suggest that E-Interventions prevent or restrict the development of the therapeutic alliance between therapist and patient[18], and as E-Interventions occur in private spaces, difficulties may also arise in relation to motivation and compliance[19], potentially leading to increasing attrition or non-compliance[19]. In light of the potential advantages and limitations of E-interventions for alcohol misuse, a number of meta-analyses have examined their effectiveness in student populations[20–23].

Nine meta-analyses have examined the efficacy of E-Interventions at reducing alcohol consumption in the general population [5,13,20,24–29]. In eight of the nine meta-analyses a small significant effect was found in favour of E-interventions in the short-term (<4 months). However, no effect has been shown past 12 months, and it is unclear whether these results generalize to a college/university population, who are potentially more 'at risk' through the prevalence and acceptability of binge drinking within their cultural context.

To date there have been six meta-analyses and narrative reviews that have examined both face-to-face and E-Interventions that target hazardous drinking in the student population [23,30–34]. These have found strong support for brief motivational interventions combined with personalised feedback, with intervention effects lasting up to 6 months. However, this raises the question of whether these interventions are still effective with students who are not yet drinking to a hazardous level. Furthermore, the fact that face-to-face and E-Interventions were combined in these meta-analyses and reviews, somewhat limits our ability to draw conclusions about the efficacy of the latter.

Three meta-analyses have examined E-Interventions on their own in student populations[21,35,36], including first year college students and mandated college students, in other words those who had broken campus policy on drinking. The most recent meta-analysis using a general student population undertaking an E-Intervention was published in 2012[36].Their results showed E-Interventions were effective at reducing drinking (d_+s=0.07 – 0.14). However, this meta-analysis only included studies publication up until 2011. Since then there have been 13 additional RCTs evaluating the efficacy of E-Interventions at reducing alcohol consumption in students. Some of these new studies have trialled new forms of E-Interventions, thought to be better suited for this population[33]. Furthermore, given the rapid changes in technology that students have access to, there is now a wider variety of means of offering E-interventions to students[37]. Therefore, a new meta-analysis of the efficacy of E-Interventions for student alcohol misuse is timely.

To this end, the current meta-analysis aimed to: (i) provide an up to date assessment of the extent to which E-Interventions reduce the number of alcoholic drinks a student consumes per week relative to assessment only controls; and (ii) carry out a moderator analyses examining whether their effectiveness has increased over time, whether E-Interventions are better suited for students who have already been classified as being 'at risk' drinkers, and whether web-based personalised feedback remains the most effective form of E-Intervention.

Method

Search strategy and study selection

Studies were retrieved from the following electronic databases from the inception of the database to June 2017: Cochrane library, CINAEL, ERIC, MEDLINE, PsycINFO, PubMed,

and Web of Science. The search string was: (alcohol OR drink*) AND (college OR university OR undergraduate* OR student) AND (RCT OR "randomised controlled trial" OR "randomised controled trial" OR "randomized controlled trial" OR "randomized controlled trial") AND (computer OR internet OR intranet OR DVD OR email OR text OR app* OR *phone OR SMS OR telehealth OR tele-health OR eHealth OR e-health OR mhealth OR m-health OR smart*). After the studies were retrieved, a screening process was conducted following the PRISMA protocol. The studies were included if: (i) they were a randomised controlled trial (RCT); (ii) the intervention was an E-intervention, in that the intervention was delivered via a technological device,; (iii) the participant group was solely composed of those entering or current college/university students, this took into account that the term 'college' in the UK is the equivalent to American senior high schools (students between 16-18) and therefore studies looking at this age group were excluded; (iv) the study was published in English in a peer reviewed journal, (v) the necessary data could be accessed from either the paper or was provided by the authors, and (vi) the study investigated the effect of the chosen intervention on the number of drinks the student consumed in a week.

To see if any further relevant studies could be found, the first author hand searched the reference sections of the selected papers. In addition, the last four years' worth of issues of the four most frequent journals among the selected studies, namely *Addictive Behaviour, Psychology of Addictive Behaviour, Journal of Consulting and Clinical Psychology and BMC Public Health*, were hand searched for missing articles.

Figure 1 illustrates the search and screening process in a PRISMA diagram. The initial search produced 1,669 studies and 85 were identified by hand-searching. Twenty-three of these met criteria for inclusion in the meta-analysis[5,38–59].

Study quality

The quality of the studies was assessed using the JADAD scale, which produces a rating of zero to five, with five indicating the highest quality [60]. All of the papers were rated independently by two raters. The ratings were identical for 18 out of the 23 papers. For five studies, the raters disagreed by one point and for one study by two points. After a discussion between the raters, an agreement was reached on the score for all papers (see Table 1).

Data analysis

The between group, post-intervention means, sample sizes and standard deviations for the measure of drinks per week were extracted and entered into Review Manager (Revman) version 5.3. The following formula was used by Revman to calculate post-intervention between group effect sizes:

$$SMD_i = \frac{m_{1i} - m_{2i}}{S_i}\left(1 - \frac{3}{4N_i - 9}\right)$$

Where,

$$S_i = \sqrt{\frac{(n_{1i} - 1)sd_{1i}^2 + (n_{2i} - 1)sd_{2i}^2}{N_i - 2}}$$

'Drinks per weeks'[61] was selected to provide a standardised measurement across all of the studies and as it can be regarded as a broad way of determining the effectiveness of an intervention. For all studies, the assessment only control condition was selected as the comparator, as every study included such a control group, but few included an active control condition. If the study included multiple intervention conditions, the condition that most closely fitted the description of an E-intervention was selected. If multiple versions of that intervention were being used (e.g. a basic format vs. more elaborate E-intervention), then the more sophisticated intervention was selected. Due to the range of different interventions used

in the analysis, a random effects model was employed to account for differences between the interventions.

A forest plot of post-interventions between-group effect sizes was produced using RevMan. Comprehensive meta-analysis (CMA) software (Professional version) was employed to run a meta-regression between the quality ratings and effect sizes. To explore publication bias, a funnel plot was produced using RevMan, and Rosenthal's failsafe N [62] was calculated using the Excel spread sheet produced by De Coster and Iselin (available from http://www.stathelp.com).

Results

Study outcomes

While many of the studies tested a variety of factors, the primary outcome for our analysis was drinks per week (DPW). Studies measured this in a variety of ways, including asking participants to report their alcohol consumption over the course of a day, week or month, which were all transformed by the studies to provide a weekly consumption. There was also variation in how these data were captured. Some studies asked participants to upload information each day on to an app or website, while others asked the participants to recall their consumption at the end of the week or month. While research has shown this to be an accurate method of collecting data when participants had consumed a low to moderate amount of alcohol, participants often under-estimate their consumption after a heavy drinking episode[63].

Study Characteristics

The characteristics of included studies are presented in Table 1. The study publication dates ranged across 13 years from 2004 to 2017. The number of participants included in the meta-analysis was N=7,614 (E-intervention n=3,617, assessment only n=3,997). The majority

of studies came from the USA (k=16), with the second most common setting being the UK (k=3). The four remaining papers came from Canada, Sweden and the Netherlands respectively.

The majority of participants were recruited by opportunistic sampling (*k*=18), using either students who were about to start college/university or current college/university level students. 1,011 of the 7,614 participants within the sample were college/university students who had either been mandated by their college/university for breaking campus alcohol policies or through the initial screen had been identified as at risk/heavy drinking students.

Interventions used

The most common E-intervention was Web-based personalised feedback (k=17), with phone-based interventions being the second most common (k=2), and education-based interventions and theory based interventions each being employed in only one study. These interventions are now described in more detail.

Web-based personalised feedback

Web-based personalised feedback interventions seek to provide participants with feedback on the amount of alcohol they have been drinking, their average blood alcohol concentration (aBAC), the amount of calories consumed, and their level of consumption compared to the recommended guidelines set by the country they are in. The feedback is personalised by the participant submitting their own information to the intervention, which then provides the participant with feedback depending on their consumption.

Education based

Education based interventions seek to educate the participants about possible risks or harm they could face due to their drinking. This can range from the personal harm they could experience, to the damage drinking related behaviour is having on the surrounding area they live in and the community. Personal harm could be in the form of the damage excessive alcohol can have on their body and the risks it can have on mental health.

Phone based

Phone based interventions refer to the means by which the intervention can be delivered, as personalised feedback, education based interventions and brief motivational interventions can be offered via phone. Most phone based interventions work by sending the participant the outcome of their personalised feedback and/or by sending them motivational messages or facts about drinking, to help keep the participant on track with the intervention or to help shift the participant's behaviour.

Study quality

The study quality scores are presented in Table 1. Half of the studies achieved a JADAD score of 3 out of 5, and the remainder had lower scores. One of the most common reason for dropping two points was the failure to double-blind, which can be challenging in the context of interventions of this nature. No significant association was found between the studies' effects size and the JADAD scores, ($Z=.37$, $p=.71$), suggesting that study quality did not affect the sizes of the outcomes obtained.

Publication bias

A funnel plot was created to test for publication bias (Figure 2). As this showed an asymmetry, there may be some publication bias in the literature. However, a Rosenthal's Fail

Safe N showed that an additional 313 studies showing no intervention effect would be needed to reduce the overall effect size to non-significance, suggesting that the findings are robust.

Main analysis

The test for heterogeneity in effect-sizes was not statistically significant ($\chi^2(22)$= 29.25, p = 0.14, I^2 = 25%). This supports the inclusion of this group of studies in a meta-analysis, and the combining of their findings into one pooled effect-size. The test for the overall effect found a small, but highly significant, effect (Z = 4.80, p< 0.00001, SMD = -0.15, CI 95% [-0.21, -0.09]). Thus, E-Interventions are effective at reducing the number of alcoholic drinks students consume per week compared to assessment only controls.

Moderator analysis

Three moderator analyses were conducted.

At risk vs. any drinkers

Studies were included in the 'at risk' category if they had given their participants a pre-intervention test to assess their drinking behaviour and had found the drinking to be at harmful levels. The test for the overall effect for the 'at risk' students was not significant (Z = 1.88, p=0.06, SMD = -0.20, CI 95% [-0.40, 0.01]). The test for the overall effect of the 'any drinkers' showed a significant, small effect (Z = 5.29, p< .00001, SMD = -0.13, CI 95% [-0.18, -0.08]). However, the test for sub-group differences was not significant, ($\chi^2(1)$ = 0.35, p = 0.55).

Publication date

A comparison was run between studies that were published before 2012 and those that were published subsequently. This date was selected as the most recent meta-analysis in this area had included studies up to 2011. For the earlier studies, there was a significant effect in the small to medium range (Z = 3.13, p=0.002 .0001, SMD = -0.24, CI 95% [-0.39, -0.09]),

and for the later studies, there was also a significant, small effect (Z = 3.67, p=0.0002, SMD = -0.1, CI 95% [-0.16, -0.05]). The difference between these sub-groups was marginally significant, but did not reach full significance ($\chi^2(1) = 2.77$, p = 0.1). Thus there was tentative evidence that more recent studies may have smaller effect sizes than pre-2012 ones. However, when year of publication was used as a continuous predictor in a meta-regression it was non-significant Z=.94, p= .35.

Web-based personalised feedback vs. other interventions

A comparison was run between studies that were conducted using a web-based personalised feedback and those that used other types of interventions. The studies were selected for the web-based personalised feedback group if the intervention had been described using the term 'personalised feedback' and had been delivered using email, website or web-based technology. For the web-based personalised feedback interventions, there was a significant effect in the small to medium range (Z = 4.69, p<0.00001, SMD = -0.19, CI95% [-0.27, -0.11]). For the other interventions, there was no significant effect (Z = 1.84, p=0.07, SMD = -0.07, CI95% [-0.14, 0.00]). Overall, there was a significant difference found in the effect size between these two sub groups, ($\chi^2(1) = 5.30$, p = 0.02). The forest plot associated with this moderation analysis is shown in Figure 3.

Follow up

Some studies collected additional outcome data at follow-up time point(s), after the post-intervention time-point. Therefore, an analysis was conducted, comparing drink per week for E-Interventions with assessment only controls at follow-up. In cases where a study had more the one follow-up time point, the longest follow-up for which data were available was included. This resulted in six studies being included, with their included follow-ups ranging from 6 to 12 months' post-intervention. The forest plot can be seen in Figure 4. No

significant difference between the groups was found (Z = 1.31, p=0.19, SMD = -0.05, CI 95% [-0.12, 0.02]).

Discussion

This meta-analysis examined the effectiveness of E-Interventions compared to assessment only controls at reducing the number of alcoholic drinks college/university students drank per week. 56.52% (i.e. *k* =13) of the included studies were published since the last meta-analysis that specifically examined such E-Interventions in students, confirming the need for a new meta-analysis. Furthermore, the low level of heterogeneity between the included studies makes it credible to argue that they were testing similar enough interventions to be combined in a meta-analysis.

The results showed a small, significant reduction in drink per week following E-Interventions relative to assessment only controls. This overall finding is consistent with previous meta-analyses [21,23,33,34], and adds to the growing pool of evidence that E-Interventions can support students in reducing their daily drinking. In addition, web-based personalised feedback was found to be the most effective of the E-Interventions, while there was not good evidence of a difference in efficacy of E-Interventions between 'at risk' and 'any drinkers'.

However, the beneficial effects of E-Interventions disappeared after 6 to 12 months, since the intervention and control conditions no longer significantly differed in the analysis of the follow-up data. Therefore, future research could helpfully focus on maintaining treatment effects over a longer time period. In addition, the most surprising finding was the tentative evidence towards more recent studies showing smaller effects compared to pre-2012 trials. This result does not appear to be driven by any changes in study quality that may have occurred over time, since the latter was not associated with effect size. However, the apparent

decline in effect size over time should be treated with some caution, given that it was only marginally significant. If this trend is found to be robust in future meta-analyses conducted after further RCT have been completed, then it would be a cause for concern. By way of comparison, it is interesting to note that a decrease in the efficacy of interventions over time has been found in a meta-regression of interventions for depression[64].

Implications and limitations

Based on the current findings, the use of E-Interventions, and in particular web-based personalised feedback, appears warranted for both 'at risk and 'any' student drinkers. However, these interventions may need to be repeated 6 to 12 months after the first 'course' of the intervention has been completed, since their treatment effects do not appear to be maintained at 6 to 12 month follow-up.

The main limitations of this meta-analysis are that: (i) a small number of studies examined interventions other than web-based personalised feedback, limiting the extent to which the efficacy of different types of interventions could be compared; (ii) there was some suggestion of publication bias, which may have led to an over-estimation of the effects of the interventions; (iii) there were too few trials with active control groups to conduct a meta-analysis of E-Interventions versus such controls, which would have been a more stringent test of their efficacy; and (iv) generally participants' self-reported alcohol consumption was relied upon to measure outcomes, the limitations of which have already been described.

A technological advance that appears to have the potential to address this latter limitation is the recent development of wearable technology that can measure blood alcohol levels[65]. Assuming that such technology can demonstrate satisfactory reliability and validity of measurement at an affordable cost-base, it could be used in trials to generate outcome

measurements that would likely have greater validity than self-report. In addition, it would also appear to have the potential to support more efficacious personalised-feedback E-Interventions, since the feedback would be based on a more accurate measurement of participants' alcohol consumption than in the current interventions, which rely on self-report. Therefore, feasibility RCTs evaluating such an approach would seem a helpful next step for the field.

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Table 1

Characteristics of the studies included in the meta-analysis

Footnote: (Target group) UStd = University students, MUStd = Mandated university students, HdUStd = Heavy drinking university students. (Nature of Intervention) Wb-PF = Web-based personalised feedback, Wb-PF+SN = Web-based personalised feedback with social norms, PhD-BMI = Phone-delivered brief motivational intervention, Tb-HBI = theory-based online health behaviour intervention, PhD-BI = Phone delivered brief intervention. Wb-PF+BI = Web-based personalised feedback and brief intervention, Wb-PF+Edu = Web-based personalised feedback and education intervention. FB+ST = Feedback and skills training. PBS = Protective behavioural strategies

Figure 1: Flow of information from collection to inclusion of studies.

Figure 2: A funnel plot of post-intervention effect sizes by standard error.

Figure 3. Forest plot for post-intervention between-group effect sizes for the web-based personalised feedback vs. other interventions.

Figure 4. Forest plot for post intervention overall effect for the available follow up results.