Prev Sci 17(6), 659-678.
DOI 10.1007/s11121-016-0662-3

A Meta-Analysis of the Impact of Universal and Indicated Preventive Technology-Delivered Interventions for Higher Education Students

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Abstract The uses of technology-delivered mental health treatment options, such as interventions delivered via computer, smart phone, or other communication or information devices, as opposed to primarily face-to-face interventions, are proliferating. However, the literature is unclear about their effectiveness as preventive interventions for higher education students, a population for whom technology-delivered interventions (TDIs) might be particularly fitting and beneficial. This meta-analytic review examines technological mental health prevention programs targeting higher education students either without any presenting problems (universal prevention) or with mild to moderate subclinical problems (indicated prevention). A systematic literature search identified 22 universal and 26 indicated controlled interventions, both published and unpublished, involving 4763 college, graduate, or professional students. As hypothesized, the overall mean effect sizes (ESs) for both universal (0.19) and indicated interventions (0.37) were statistically significant and differed significantly from each other favoring indicated interventions. Skill-training interventions, both universal (0.21) and indicated (0.31), were significant, whereas non-skill-training interventions were only significant among indicated (0.25) programs. For indicated interventions, better outcomes were obtained in those cases in which participants had access to support during the course of the intervention, either in person or through technology (e.g., email, online contact). The positive findings for both universal and indicated prevention are qualified by limitations of the current literature. To improve experimental rigor, future research should provide detailed information on the level of achieved implementation, describe participant characteristics and intervention content, explore the impact of potential moderators and mechanisms of success, collect post-intervention and follow-up data regardless of intervention completion, and use analysis strategies that allow for inclusion of cases with partially missing data.

Keywords Mental health · Prevention · Meta-analysis · Technology · Higher education

Technology-Delivered Mental Health Interventions

Technology-delivered interventions (TDIs) use technology as the major delivery vehicle for providing health services. These services can be administered, for example, through computer- or Internet-based programs, mobile devices, video conferencing, interactive television and voice response systems, DVDs, personal digital assistants, or virtual reality experiences (Robert Wood Johnson Foundation 2010). The field of technology-delivered *mental* health intervention, which has been discussed using a variety of terms such as behavioral intervention technologies, cybertherapy, eMental health, e-therapy, internet therapy, and telemental health, has considerable potential. For example, TDIs may be able to reach large numbers of people through convenient, easily-accessible, stigma-reducing, and cost-effective means (Portnoy et al. 2008; Proudfoot 2004; Tate and Zabinski 2004). They can be uniform and standardized across users, or customized to provide individualized content, personalized feedback, and interactive exercises (Atkinson and Gold 2002; Portnoy et al. 2008), which can stimulate the learning and application of new skills. Further, TDIs can be particularly advantageous in terms of real-time assessment of moods and behaviors, prompts to

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encourage compliance and homework completion, and monitoring of intervention engagement and adherence (Harrison et al. 2011; Stone et al. 2003). Emerging evidence from individual studies and meta-analyses has demonstrated the promise of TDIs for treating various adjustment problems in youth (e.g., Christensen et al. 2010) and adults (e.g., Barak et al. 2008; Cavanagh and Shapiro 2004). Treatments offered through TDIs have been found to be comparable to face-to-face (FTF) approaches (Cuijpers et al. 2010; Harrison et al. 2011).

Prevention Through Technology in Higher Education

Technology is a promising approach for preventing mental health problems in higher education students. The vast majority of higher education students have smart phones, personal computers, and/or tablets (Roberts et al. 2014; Smith 2013), and many use their technology devices to access health information (Fox and Duggan 2012; Gray et al. 2005). Furthermore, given the success of TDIs in adult treatment studies on problems such as depression and anxiety (Bee et al. 2008; Richards and Richardson 2012), it seems likely that TDIs can be used preventively with higher education students for the same problems. This is potentially very important because depression and anxiety are common difficulties experienced by higher education students (American College Health Association 2014; Center for Behavioral Health Statistics and Quality 2014; Conley et al. 2014).

Several outcome studies of technology-delivered mental health prevention programs for higher education students have appeared in recent years. Most use computers to deliver interventions, while others have used mobile phones (e.g., Grassi et al. 2011), or audiotapes or videotapes (e.g., Ayres et al. 1993; McFall and Lillesand 1971). For example, Cukrowicz and Joiner (2007) evaluated the efficacy of a computer-based universal prevention program to reduce mild anxiety and depressive symptoms in college students. During a 2-h session, participants used a computer program to engage in exercises, analyzing specific interpersonal incidents and reframing maladaptive thoughts. Following the TDI, over the next 8 weeks, students were given worksheets to complete on real-life stressful encounters, related thoughts and behaviors, and more adaptive alternatives that may have led to a desired outcome. At the conclusion of this 2-month home-practice period, the intervention group reported significantly lower symptoms of depression and anxiety compared to the control group. In another study, over a 6-week period, university students who had elevated symptoms of depression, anxiety, and stress completed various Internet-based modules that involved such cognitive-behavioral activities as behavioral activation, thought labeling and challenging, and relaxation exercises (Day et al. 2013). A program coach contacted participants weekly by phone or email to give support and clarify program information, and monitor participant responses to ensure correct implementation of the techniques, but did not give therapeutic advice. Participants improved significantly on depression, anxiety, and stress compared to waitlist control participants.

Reviews involving higher education samples have offered evidence for the positive impact of preventive TDIs targeting alcohol use (Carey et al. 2009; Elliott et al. 2008; Tait and Christensen 2010; Walters et al. 2005) and eating and weight problems (Beintner et al. 2012; Laska et al. 2012). However, among systematic reviews involving higher education students, only two have focused on the use of technology for preventing mental health problems, outside of these circumscribed areas (Davies et al. 2014; Farrer et al. 2013). Although these reviews have offered positive data on the effectiveness of preventive TDIs, both have indicated the need for more rigorous evaluation. These reviews also have limitations. Both only included published randomized trials, and one only contained 17 studies of website- and computer-delivered interventions (Davies et al. 2014). Farrer and colleagues (2013) focused on undergraduates specifically and based their major conclusions on whether or not statistically significant differences were obtained between intervention and control groups (i.e., vote counting). The most serious problem in both reviews is that studies of universal and indicated prevention, as well as some therapy studies (treatment for clinical disorders), were combined in the analyses. This confounding of different intervention strategies precludes understanding how effective technology can be when used as either a universal or an indicated approach.

The Current Meta-Analysis: Goals and Hypotheses

The current meta-analysis sought to evaluate separately the impact of both universal and indicated TDIs targeting the mental health adjustment of higher education students. Also improving upon the limitations of previous reviews, we included published and unpublished reports, and randomized or quasi-experimental control designs. We predicted that both universal and indicated TDIs would yield significant mean effects at post-intervention. Based on comparisons made in other meta-analyses involving youth or adults (e.g., Stice et al. 2006; Wilson et al. 2001), we also predicted that indicated interventions would yield significantly higher effects than universal ones. Because two recent meta-analyses of universal (Conley et al. 2015) and indicated (Shapiro et al. 2015) FTF interventions used comparable procedures to search for,

code, and analyze the results of studies, we also were able to compare current findings for TDIs with FTF programs.

Impact of Skill Training

In a recent meta-analytic review of over 100 FTF universal preventive interventions for higher education students, programs that incorporated supervised practice of targeted skills were significantly more effective than psychoeducational programs and skill-training programs that did not incorporate supervised practice (Conley et al. 2015). Therefore, we also predicted that skill-training interventions, specifically those containing elements reflective of supervised practice (see Method), would be most effective.

Additional Potential Moderators

We also sought to evaluate how several methodological and intervention features might moderate program outcomes, in an exploratory fashion. Based on inconsistent findings in reviews of mental health TDIs for adults, we were particularly interested in:(a) the rate of attrition from the study, (b) intervention dosage, and (c) intervention support. For example, rates of attrition have varied considerably across technological interventions, as have data designed to estimate how much of the intervention is actually completed by participants (i.e., dosage; Bee et al. 2008; Christensen et al. 2009), and these variables have been linked to mental health outcomes (Donkin et al. 2011; Lamers et al. 2012). Attrition can occur because participants do not complete post-intervention assessments, but that does not mean that dropouts failed to complete the intervention program or that those who remained in the study actually completed all of the program and thus received the full dosage of the intervention. Past research also has been unclear about the conditions in which intervention support (whether in person or via technology) enhances outcomes for TDIs (e.g., Andersson and Cuijpers 2009; Grist and Cavanagh 2013; Mohr et al. 2011; Newman et al. 2011; Spek et al. 2007). Because of the inconsistent results obtained in prior TDI treatment research on adults, we did not have specific hypotheses about the influence of attrition, dosage, or support on program outcomes.

Method

Search Strategy and Report Selection

We used three major systematic search strategies in an attempt to assemble a nonbiased, representative sample of published and unpublished investigations. First, we performed searches for reports appearing through the end of 2014 in seven databases: PsycINFO, ERIC, ProQuest Digital Dissertations, MEDLINE, PubMed, Web of Science, and Cochrane Collaboration. We used a combination of several groups of search terms to find studies meeting our criteria for interventions, participants, and use of technology (e.g., prevention, university, college student, mobile, computer, online, e-health). Second, we hand-searched the contents of 95 selected journals most likely to publish studies on mental health interventions involving higher education students, going back at least five years from the end of our computer searches, to capture studies missed by our other search techniques. Third, we inspected the reference lists of each study meeting our criteria and also of relevant previous reviews (e.g., Barak et al. 2008; Christensen et al. 2010; Davies et al. 2014; Farrer et al. 2013; Newman et al. 2011; Spek et al. 2007).[1]

To be included in our final sample, the reports had to meet six criteria: (a) Evaluate a *universal* or *indicated* preventive intervention aimed at improving mental health; (b) target higher education students (college, graduate, or professional); (c) include a control group (e.g., wait-list, no intervention, or placebo), with at least 10 participants in each condition; (d) contain at least one quantitatively assessed mental-health-related outcome measure (described below) for which effect sizes could be calculated; (e) examine an intervention delivered primarily by means of technology, including a computer program or website, a mobile device application, audio or video tapes or discs, or a virtual reality application; and (f) appear in English. Interventions with a primary focus on academics, physical health, eating disorders, body image, and substance use were not included, as these areas were outside the general mental health focus of our review.

Figure 1 shows the flow of sample selection and inclusion. The initial database searching procedures outlined above identified 7628 reports for potential inclusion, of which 7003 were deemed irrelevant upon initial screening. The remaining pool of 625 reports were further screened using our specific inclusion criteria, eliminating 573 studies. Among the 52 remaining eligible reports, six contained variants of the same intervention, changing small components of the intervention or its duration but retaining the same active component. In such cases, we only included the intervention that was most comprehensive or most fully technology-based (i.e., contained the most elements, was longer in duration, or used technology more exclusively). If more than one conceptually distinct intervention was evaluated in the same report (e.g., psychoeducational and cognitive-behavioral techniques, see below), each intervention was coded separately. In cases where means and standard deviations were not included in the original reports or effects could not be calculated because

[1] A copy of the search terms, the journals and reviews that we hand searched, and our coding manual are available from the authors on request.

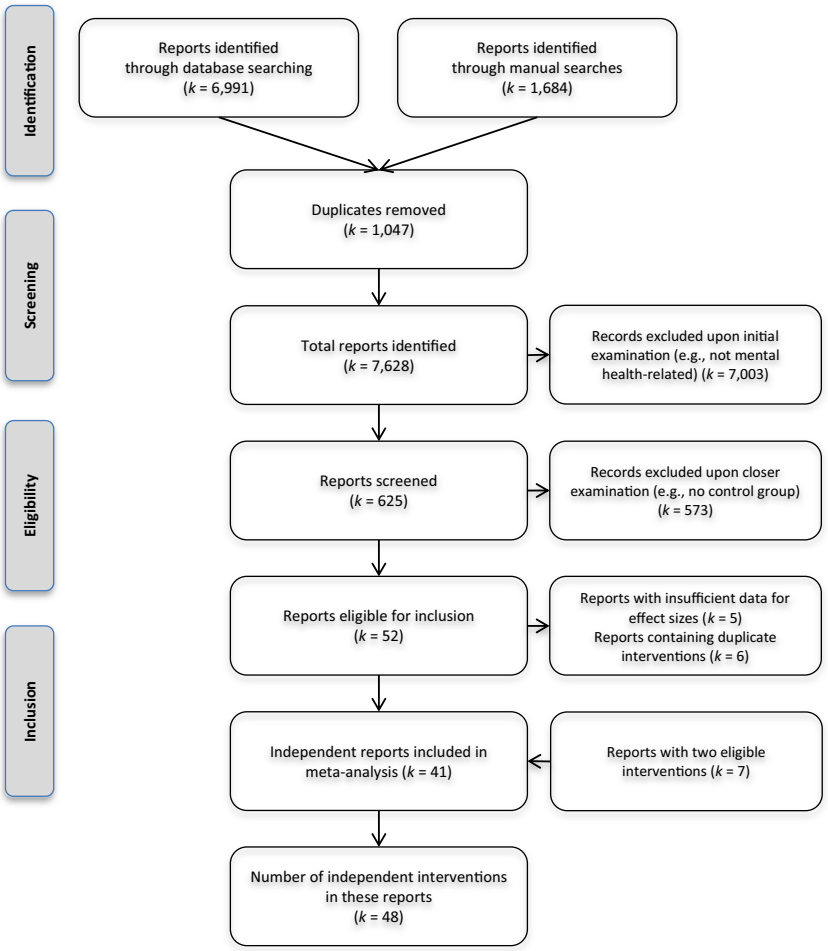

Fig. 1 Flow of information through the different phases of the review

of insufficient data ($k = 22$), we contacted as many of the study authors as possible in order to secure the missing data. After author responses and ES estimation procedures were considered, we had to exclude five reports for which no ESs could be calculated on any outcome measure. This screening process led to a final sample of 48 interventions, contained in 41 reports appearing between 1970 and the end of 2014.

Study Coding

Studies were coded on relevant outcomes assessed, as well as on various intervention, participant, and design features, several of which are explained below.

Type of Prevention

Studies were coded as either (a) *universal* prevention if the participants did not have any preexisting mental health problems or (b) *indicated* prevention if participants either met criteria for mild to moderate (subclinical) levels of problems based on some screening mechanism, or had acknowledged some existing problems or symptoms (e.g., high stress, depression, or anxiety).

Primary Intervention Strategy and Focus on Skill Training

Each intervention was coded on its main strategy of mental health prevention. Intervention strategies included the following: (1) *cognitive-behavioral (CBT)* interventions that focused on monitoring and modifying cognitions, identifying emotions, and changing behaviors in order to improve adjustment; (2) *mindfulness* interventions that used techniques such as those developed by Kabat-Zinn (1990) to train the mind to function in a nonjudgmental and present manner; (3) *psychoeducational* interventions that emphasized providing information to participants (e.g., on how to cope or deal with stress or mental health issues); (4) *social skills* interventions that focused on building assertiveness or social support; (5) *relaxation* interventions that used strategies such as progressive muscle relaxation; (6) *online support group* interventions,

which facilitated discussion among participants via online chatrooms and other interactive web-based platforms; and (7) an *other* category that included unique interventions that did not fit into the above categories, such as a concreteness training intervention, an emotion perception training intervention, and an interactive gaming intervention.

Each intervention was further categorized as skill training or not, based on whether it was designed to develop skills, which included primarily cognitive-behavioral, relaxation, mindfulness, and social skills strategies. Interventions that were not skill training included primarily psychoeducational interventions, plus a few others that did not focus on skills.

Content of Intervention

We categorized the content of interventions along three dimensions that would approximate a supervised skills practice construct: (a) did participants have the opportunity to *practice* a new technique or skill as part of completing the intervention; (b) did the intervention contain homework assignments in which participants would continue to practice and then *apply newly-learned skills in real life situations*; and (c) did the participants *receive any type of feedback* on their skill-related responses or performance. Unfortunately, there was not enough consistency in how researchers assessed and reported different aspects of intervention content, so we were unable to assess how these elements might have enhanced intervention effectiveness.

Type of Technology Used

The interventions were coded according to the primary device used. We distinguished between newer and older technologies, so that we could examine whether the type of technology had an impact on intervention effects. *New technology* categories included (a) *computers* (including local computer programs, websites, chatrooms, or discussion boards) and (b) *mobile devices* (including phones and tablets, whether employing mobile applications, or playing audio or video files). *Older technology* categories included (c) DVD players, (d) audiotape players, and (e) VCRs.

Sample Size and Attrition

Study sample size was based on the number of participants at baseline, and attrition rates thus reflect the percentage who subsequently withdrew during the intervention and/or did not complete the post-intervention assessment.

Program Dosage

We coded for program *dosage*, or completion rate of the intervention. We found that among the reports that included dosage data, the most common information was the percentage of participants who completed the entire TDI.

Available Support: Level and Nature

We divided interventions into two categories based on the level of support that was available: (a) *self-administered* interventions, in which assistance was provided only for assessment purposes or to offer a brief introduction to the technology, and (b) *supported* interventions, in which some additional form of assistance was provided, such as prompts, reminders, feedback, or guidance through emails, and/or some personal monitoring of the intervention. We also coded for the primary nature of the available support, including (a) in person (whether one-on-one or in a group) or (b) via technology (including email or other online contact).

Relevant Outcomes Assessed

The relevant mental-health-related outcomes assessed in our sample of studies were classified into nine possible categories: (a) *depression*; (b) *anxiety*; (c) *stress*; (d) *general psychological distress*, which primarily consisted of state measures of affect or mood; (e) *health*, including measures of substance use, sleep, exercise, and other health-related behavior patterns; (f) *social and emotional skills*, which included different types of affective, cognitive, and social skills related to effective coping strategies, mindfulness practices, developing rational beliefs, or emotional self-awareness and regulation; (g) *self-perceptions*, which consisted primarily of measures of self-esteem or other self-evaluations; (h) *interpersonal relationships*, which primarily included measures of relationship satisfaction or quality, communication, conflict, and perceived social support; and (i) *spiritual outcomes*, such as spiritual growth and religious coping.

Reliability of Coding

A team of six coders, including the authors, reviewed and coded the interventions. After an initial training phase, the mean percentage agreement rate across pairs of coders on a subsample of 42 interventions was acceptable across codes (mean 96.61 %, range 79 to 100 %). The few discrepancies encountered were resolved through discussion.

Meta-Analytic Strategy

Effect Size Calculation and Estimation

Using Comprehensive Meta-Analysis Version 3 (CMA-V3; Borenstein et al. 2014), we calculated effect sizes for 335 outcomes at post-intervention and 130 outcomes at follow-

up (ranging from 2 weeks to 12 months), using Hedge's *g* (referred to below as ES, for effect size). For four studies, we used the provided model-based estimates of effect sizes using missing data strategies (e.g., maximum likelihood estimation, baseline-carried-forward analysis, or last observation carried forward analysis) that allowed for inclusion of cases with partially missing data in their analyses (Cavanagh et al. 2013; Day et al. 2013; Musiat et al. 2014; Pless 2010). A sensitivity analysis revealed no significant differences on outcomes when these four studies were excluded. Positive ES values reflect the superiority of the intervention over the control group. When means and standard deviations were not available through the reports or author contacting, we generated estimates of ES using procedures described by Lipsey and Wilson (2001). If multiple measures within the same study fell into the same outcome category (e.g., two or more measures of depression), these ESs were averaged to yield one effect per outcome category per intervention.

When the only information provided in the report indicated that an ES was nonsignificant, we conservatively set that ES to zero. Before conducting any analyses, we identified seven outlier ESs and one outlier sample size (i.e., whose values were more than three standard deviations from the mean of their respective distributions) and set these values at three standard deviations in order to retain these data points (as suggested by Lipsey and Wilson 2001).

Whenever possible, we adjusted post-intervention and follow-up ESs for pre-intervention baseline outcome levels to provide a more accurate estimate of differential change over time (e.g., in some cases, the control group was superior to the intervention group at pre but not at post). This was done by subtracting the pre-intervention ES from the post-intervention or follow-up ES, similar to procedures in other meta-analyses (Durlak et al. 2010; Wilson et al. 2001). We used random effects modeling to increase the generality of our findings and calculated 95 % confidence intervals (CIs) around each obtained mean ES.

Effect Size Comparisons

Mean ESs whose 95 % CIs did not include zero were considered statistically significant at the $p < .05$ level. We followed the guidelines of Cumming and Finch (2005), who emphasized that interpreting significance only when the CIs of means do not overlap is too conservative. In their approach, CIs with less than 50 % overlap are considered statistically different at the $p < .05$ level. We also inspected I^2 values as an index of heterogeneity for group means, using the guideline of 25 % as a low degree of heterogeneity, 50 % as a moderate degree, and ≥75 % as a high degree of heterogeneity (Higgins et al. 2003).

Results

Descriptive Information on Review Sample

Table 1 provides descriptive information about all 48 interventions combined, and separately for the 22 universal and 26 indicated interventions, which contained a total of 3003 and 1760 participants, respectively. Overall, nearly 60 % of the interventions appeared since 2010 (and nearly 90 % since 2000), and 31 % were unpublished. Approximately two-thirds of the interventions were conducted in the USA, and all but one intervention used a randomized design. There was a wide range of initial sample sizes (mean = 103; range = 24–1047), the average attrition rate was only 16 %, and differential attrition averaged only 6.50 %. On average, participants were 70 % female and 35 % non-Caucasian, although ethnicity was only reported in 54 % of the interventions. The majority of interventions (77 %) were skill training, and the most common intervention strategy was cognitive-behavioral (50 %). The majority of interventions (83 %) were delivered via a computer. Seventy-five percent of the interventions were self-administered (with no contact or minimal support for administrative aspects only); only 23 % were supported, with some in-person or via-technology support provided beyond brief introductions, orientation, or assessment. The average duration of all interventions was fairly brief (mean = 2.34 h; range <1 to 10 h). There were only two statistically significant differences in the characteristics of the universal and indicated study samples. A significantly greater proportion of universal than indicated interventions targeted first-year students, χ^2 (3) = 9.14, $p = .027$, and were self-administered, χ^2 (1) = 7.76, $p = .005$.

Effectiveness at Post-Intervention

Overall Effectiveness of Interventions

Table 2 provides general information about each of the 22 universal and 26 indicated interventions. We first averaged the ESs across all outcomes within each intervention to yield one intervention-level effect. As predicted, the overall mean ESs for both universal interventions (ES = 0.19, CI = 0.11 to 0.28; $k = 22$, $p < .001$) and indicated interventions (ES = 0.37, CI = 0.27 to 0.47; $k = 26$, $p < .001$) differed significantly from zero. Also as predicted, indicated interventions yielded significantly higher mean effects than did universal interventions. Given this finding, as well as conceptual differences between the two samples, all analyses were conducted separately for universal and indicated interventions.

As displayed in Table 2, the average intervention study-level ESs for universal programs ranged from −0.25 to 0.66 and for indicated from −0.08 to 1.06. Overall, there were only five negative study-level intervention effects, and none

Table 1 Descriptive characteristics of 22 universal and 26 indicated technology-delivered preventive interventions

	All interventions ($k = 48$)		Universal only ($k = 22$)		Indicated only ($k = 26$)	
	k	%	*k*	%	*k*	%
General study features						
Date of report						
1989 or before	3	6.3	1	4.5	2	7.7
1990–1994	2	4.2	–	–	2	7.7
2000–2004	5	10.4	1	4.5	4	15.4
2005–2009	11	22.9	8	36.4	3	11.5
2010–2014	27	56.3	12	54.5	15	57.7
Publication status						
Published	33	68.8	13	59.1	20	76.9
Unpublished[a]	15	31.3	9	40.9	6	23.1
Country						
Inside the USA	31	64.6	17	77.3	14	53.8
Outside the USA[b]	17	35.4	5	22.7	12	46.2
Design features						
Experimental design						
Randomized	47	97.9	21	95.5	26	100.0
Quasi-experimental	1	2.1	1	4.5	–	–
Type of control						
No intervention/waitlist	29	60.4	10	45.5	19	73.1
Nontherapeutic information only	8	16.7	6	27.3	2	7.7
Active/attentional/placebo	11	22.9	6	27.3	5	19.2
Participant characteristics						
Initial sample size (intervention + control)						
Mean (standard deviation)	103.15	(150.34)	141.27	(213.08)	70.88	(44.61)
Median (range)	60.50	(24–1047)	76.50	(24–1047)	58.00	(26–195)
0–50	14	29.2	4	18.2	10	38.5
51–100	21	43.8	9	40.9	12	46.2
101+	13	27.1	9	40.9	4	15.4
Sample attrition ($k = 45$ reported)						
Mean (standard deviation)	16.22 %	(18.3 %)	17.76 %	(22.7 %)	14.88 %	(13.71 %)
Median (range)	10.61 %	(0–65 %)	7.72 %	(0–65 %)	11.98 %	(0–52 %)
Differential attrition ($k = 45$ reported)						
Mean (standard deviation)	6.50 %	(7.9 %)	5.62 %	(7.2 %)	7.26 %	(8.64 %)
Median (range)	3.15 %	(0–28 %)	2.75 %	(0–27 %)	4.18 %	(0–28 %)
Gender (% female) ($k = 44$ reported)						
Mean (standard deviation)	70.28 %	(20.17 %)	67.68 %	(25.55 %)	72.65 %	(13.78 %)
Median (range)	72.00 %	(0–100 %)	71.00 %	(0–100 %)	72.00 %	(45–100 %)
Ethnicity (% non-Caucasian) ($k = 26$ reported)						
Mean (standard deviation)	34.62 %	(24.25 %)	35.26 %	(27.37 %)	33.58 %	(19.56 %)
Median (range)	28.95 %	(6–100 %)	28.95 %	(6–100 %)	28.66 %	(9.5–66 %)
Type of student[c]						
First-year undergraduates	9	18.8	8	36.4	1	3.8
Other/mixed undergraduates	32	66.7	11	50.0	21	80.8
Mixed undergrad/graduates	4	8.3	1	4.5	3	11.5
Graduate/professional students	2	4.2	1	4.5	1	3.8
Type of school						
Four-year college/university	46	95.8	21	95.5	25	96.2
Graduate/professional school	2	4.2	1	4.5	1	3.8

Table 1 (continued)

	All interventions ($k=48$)		Universal only ($k=22$)		Indicated only ($k=26$)	
Intervention features						
Skill training						
Yes	37	77.1	17	77.3	20	76.9
No	11	22.9	5	22.7	6	23.1
Primary intervention strategy						
Cognitive-behavioral	24	50.0	7	31.8	17	65.4
Mindfulness	2	4.2	1	4.5	1	3.8
Psychoeducational	4	8.3	2	9.1	2	7.7
Social skills	6	12.5	4	18.2	2	7.7
Relaxation	2	4.2	2	9.1	–	–
Online support group	2	4.2	1	4.5	1	3.8
Other	8	16.7	5	22.7	3	11.5
Primary type of technology						
Computer	40	83.3	18	81.8	22	84.6
Mobile phone	2	4.2	2	9.1	–	–
DVD player	1	2.1	1	4.5	–	–
Audiotape player	3	6.3	1	4.5	2	7.7
VCR	2	4.2	–	–	2	7.7
Available support: level						
Self-administered	37	77.1	21	95.5	16	61.5
Supported	11	22.9	1	4.5	10	38.5
Available support: nature[c]						
In person (face-to-face)	24	75.0	10	83.3	14	70.0
Via technology (emails, online)	8	25.0	2	16.7	6	30.0
Duration in hours ($k=33$)						
Mean (standard deviation)	2.34	(2.08)	2.36	(2.47)	2.33	(1.78)
Median (range)	2.11	(.32–10)	2.00	(.33–10)	2.18	(.32–7.5)

[a] All unpublished interventions were dissertations or theses

[b] Countries include Australia, Canada, Italy, the Netherlands, Norway, Romania, and the UK

[c] *k*s do not always add to 48 due to missing data in some reports

*$p<.05$; **$p<.01$

yielded a statistically significant iatrogenic effect. The I^2 within values for indicated and universal interventions indicated low to no heterogeneity (I^2s = 20.90 and 0.00 %, respectively). Application of Duval and Tweedie's (2000) trim and fill method, which can be considered a sensitivity analysis in that it adjusts for possible publication bias and missing studies, yielded a similar intervention effect for universal interventions (ES = 0.19, CI = 0.11 to 0.28) and only a slightly lower intervention effect for indicated interventions (ES = 0.33, CI = 0.24 to 0.43).

Skill-Training Interventions: By Study Level and Outcome Type

At the study level, universal skill-training interventions (ES = 0.21, CI = 0.11 to 0.31; $k=17$; $p<.001$) were associated with a significant positive effect, while non-skill-training programs were not (ES = 0.15, CI = −0.03 to 0.33; $k=5$; $p=.094$); however, these intervention types did not differ significantly from each other. Indicated skill-training interventions (ES = 0.39, CI = 0.29 to 0.50; $k=20$; $p<.001$) and non-skill-training programs (ES = 0.25, CI = 0.01 to 0.49; $k=6$; $p=.042$) were each associated with significant positive effects, which did not differ significantly from each other.

Calculating ESs across multiple outcome categories produced several cells with fewer than five studies, and these occasions are noted in parentheses in the following text. As presented in Table 3, universal skill-training interventions yielded significant effects for four of the nine outcome categories, specifically depression, anxiety, stress, and interpersonal relationships. Non-skill-training interventions only achieved significance for anxiety ($k=1$) and health ($k=3$)

Table 2 Selected characteristics of 22 universal and 26 indicated technology-delivered prevention programs for higher education students

Study	Initial sample size (intervention + control) and participants	Primary intervention strategy	Duration (all information reported)	Access location; type of technology	Dosage (% completing full TDI)	Types of outcomes targeted	Study-level ES: Hedges' *g* (SE)
Universal Preventive Interventions							
Braithwaite and Fincham (2007)	91 undergraduates	Social Skills (ePREP) [a]	1 session + weekly emails, 8 weeks	Study Site; Computer (via local program)	100% [b]	Anxiety, Depression, General Psych Distress, IP Relationships	0.17 (0.26)
		Cognitive Behavioral (CBASP) [a]	1 session + weekly emails, 8 weeks	Study Site; Computer (via local program)	100% [b]	Anxiety, Depression, General Psych Distress, IP Relationships	0.25 (0.27)
Braithwaite and Fincham (2009)	77 undergraduates F/U: 57 undergraduates	Social Skills [a]	1 session + weekly emails, 8 weeks F/U: 34.86 weeks	Study Site; Computer (via local program)	100% [b]	Anxiety, Depression, IP Relationships	0.66 (0.27)* F/U: 1.80 (0.29)**
Braithwaite and Fincham (2011)	160 undergraduates	Social Skills [a]	1 session, 6 weeks	Study Site; Computer (via local program)	100% [b]	Anxiety, Depression, IP Relationships	0.11 (0.17)
Cavanagh et al. (2013)	104 higher education students (level unspecified)	Mindfulness [a]	14 sessions, 5 modules, 3 h, 2 weeks	Distal; Computer (via website)	not reported	General Psych Distress, SE Skills, Stress	0.28 (0.27)
Chang et al. (2001)	32 Asian American male undergraduates	Online Support Group	4 weeks	Distal; Computer (via discussion board)	100%	Self-perceptions	0.26 (0.35)
Cukrowicz 2003, Cukrowicz and Joiner (2007), and Cukrowicz et al. (2009)	188 undergraduates	Cognitive Behavioral [a]	1 session + weekly emails, 3.5 h, 8 weeks	Study Site; Computer (via local program)	100% [b]	Anxiety, Depression, General Psych Distress	0.24 (0.16)
Faigin (2010)	189 first-year undergraduates	Psychoeducational (Spiritual Struggles)	1 module, .58 h, .14 weeks	Distal; Computer (via website)	32%	General Psych Distress, Health, Self-perceptions, Spirituality	−0.09 (0.29)
		Psychoeducational (College Stress)	1 module, .58 h, .14 weeks	Distal; Computer (via website)	29%	General Psych Distress, Health, Self-perceptions, Spirituality	−0.25 (0.31)
Grassi et al. (2007 and 2009)	60 commuter undergraduates	Relaxation [a]	4 sessions, .67 h, .29 weeks	Distal; Mobile Phone (video)	not reported	Anxiety, General Psych Distress, SE Skills, Self-perceptions, Stress	0.37 (0.25)
Grassi et al. (2011)	45 first-year female undergraduates	Cognitive Behavioral (Mobile/UMTS) [a]	6 sessions, .5 h, 1 week	Distal; Mobile Phone (video)	not reported	Anxiety, SE Skills	0.43 (0.26)
		Cognitive Behavioral (DVD) [a]	6 sessions, .5 h, 1 week	Distal; DVD Player (video)	not reported	Anxiety, SE Skills	0.43 (0.26)
Grey (2013)	112 female undergraduates	Cognitive Behavioral [a]	15 sessions, 3.75 h, 15 weeks	Distal; Computer (via website)	not reported	Self-perceptions, Stress	0.04 (0.27)
Jin (2007)	60 undergraduates	Other (Interactive Gaming Intervention) [a]	1 session, .33 h, .14 weeks	Study Site; Computer (via computer game)	100% [b]	Self-perceptions	0.30 (0.32)
Kanekar et al. (2009)	60 international (Indian) graduate students	Social Skills [a]	3 sessions, 8 weeks	Distal; Computer (via website)	not reported	General Psych Distress, IP Relationships, Self-perceptions	0.05 (0.31)

Table 2 (continued)

Study	Initial sample size (intervention + control) and participants	Primary intervention strategy	Duration (all information reported)	Access location; type of technology	Dosage (% completing full TDI)	Types of outcomes targeted	Study-level ES: Hedges' *g* (SE)
Kelly (1972)	24 first-year undergraduates	Relaxation [a]	30 sessions, 10 h, 6 weeks	Study site; Audiotape Player	not reported	Anxiety, Self-perceptions	−0.01 (0.39)
Levin (2013)	228 undergraduates F/U: 154 undergraduates	ACT [a]	2 modules, 1.18 h, 3 weeks F/U: 13.07 weeks	Distal; Computer (via website)	55%	Anxiety, Depression, General Psych Distress, Self-perceptions, Stress	−0.07 (0.15) F/U: −0.12 (0.16)
Levin et al. (2014)	76 first-year undergraduates	ACT [a]	2 modules, 1.37 h, 3 weeks	Distal; Computer (via website)	92%	Anxiety, Depression, SE Skills, Self-perceptions, Stress	0.38 (0.23)
Musiat et al. (2014)	1047 undergraduate and graduate students	Cognitive Behavioral [a]	5 modules, 2.5 h, 12 weeks	Distal; Computer (via website)	not reported	Anxiety, Depression	0.22 (0.10)*
Peters (2013)	65 first-year undergraduates	Cognitive Behavioral [a]	8 sessions, 3.33 h, 8 weeks	Distal; Computer (via website)	not reported	Depression, General Psych Distress, Health, SE Skills	0.03 (0.30)
Sarniak (2009)	100 first-year undergraduates	Other (Positive Psychology Intervention)	12 sessions, 2 h, 5.14 weeks	Distal; Computer (via website)	74.2%	Anxiety, Depression, General Psych Distress, Health	0.45 (0.21)*
Shin (2013)	285 first-year undergraduates F/U: 70 undergraduates	Other (Meaning-Making Intervention)	4 modules, 3 h, 6 weeks F/U: 52.29 weeks	Distal; Computer (via website)	not reported	General Psych Distress, SE Skills, Self-perceptions	0.14 (0.12) F/U: 0.17 (0.24)
Indicated Preventive Interventions							
Arpin-Cribbie et al. (2008 and 2012)	54 undergraduates	Cognitive Behavioral [a]	13 modules, 10 weeks	Distal; Computer (via website)	not reported	Anxiety. Depression, SE Skills	0.57 (0.29)*
Ayres et al. (1993)	97 undergraduates	Cognitive Behavioral (Study 1) [a]	1 session, .75 h, .14 weeks	Study Site; VCR (video)	100% [b]	Anxiety, SE Skills	0.35 (0.33)
		Cognitive Behavioral (Study 2) [a]	1 session, .75 h, .14 weeks	Distal; VCR (video)	not reported	Anxiety, SE Skills	0.96 (0.35)**
Bell (2014)	61 undergraduates	Cognitive Behavioral [a]	6 modules, 6 weeks	Distal; Computer (via email)	not reported	Anxiety, Depression, General Psych Distress, SE Skills, Self-perceptions	0.04 (0.27)
Call et al. (2014)	80 undergraduates	Mindfulness [a]	3 sessions, 2.25 h, 3 weeks	Study Site; Computer (audio recording)	50%	Anxiety, SE Skills, Stress	0.33 (0.26)
Chiauzzi et al. (2008)	157 undergraduates F/U: 149 undergraduates	Cognitive Behavioral [a]	4 sessions, 2.1 h, 2 weeks F/U: 21.79 weeks	Distal; Computer (via website)	not reported	Health, IP Relationships, SE Skills, Spirituality, Stress	0.72 (0.17)** F/U: 1.02 (0.18)**
Day et al. (2013)	66 undergraduate and graduate students	Cognitive Behavioral [a]	5 modules, 6 weeks	Distal; Computer (via website)	61%	Depression, Anxiety, Stress	0.62 (0.26)*
Ellis et al. (2011)	39 undergraduates	Online Support Group (MoodGarden)	3 sessions, 3 h, 3 weeks	Study Site; Computer (via website)	not reported	Anxiety, Depression, IP Relationships, SE Skills	1.06 (0.39)**
		Cognitive Behavioral (MoodGym) [a]	3 sessions, 3 h, 3 weeks	Study Site; Computer (via website)	not reported	Anxiety, Depression, IP Relationships, SE Skills	0.38 (0.39)
Gaffney et al. (2014)	43 undergraduates F/U: 42 undergraduates	Other (Supportive Psychotherapy/MOL)	1 session, .32 h, .14 weeks F/U: 2 weeks	Study Site; Computer (via website)	100%	Anxiety, Depression, General Psych Distress, Stress	0.09 (0.31) F/U: −0.06 (0.31)
Gibbel (2010)					not reported		

Table 2 (continued)

Study	Initial sample size (intervention + control) and participants	Primary intervention strategy	Duration (all information reported)	Access location; type of technology	Dosage (% completing full TDI)	Types of outcomes targeted	Study-level ES: Hedges' *g* (SE)
	65 undergraduates F/U: Not reported	Cognitive Behavioral (MoodGym) [a]	5 modules, 3.13 h, 5 weeks F/U: 4.36 weeks	Distal; Computer (via website)		Depression, General Psych Distress, SE Skills, Self-perceptions, Spirituality	0.07 (0.31) F/U: 0.06 (0.31)
		Psychoeducational (Here Comes the Sun)	5 modules, 3.13 h, 5 weeks F/U: 4.36 weeks	Distal; Computer (via website)	not reported	Depression, General Psych Distress, SE Skills, Self-perceptions, Spirituality	0.23 (0.29) F/U: −0.03 (0.29)
Hintz et al. (2014)	195 undergraduates F/U: 195 undergraduates	Cognitive Behavioral [a]	4 modules, 1 h, 1.43 weeks F/U: 3 weeks	Distal; Computer (via website)	65.64%	Anxiety, Depression, Self-perceptions, Stress	0.37 (0.17)* F/U: 0.52 (0.17)**
Kenardy et al. (2003) and Kenardy (2006)	83 first-year undergraduates F/U: 42 undergraduates	Cognitive Behavioral [a]	6 sessions, 6 weeks F/U: 26.14 weeks	Distal; Computer (via website)	not reported	Anxiety, Depression, SE Skills	0.59 (0.23)* F/U: 0.66 (0.31)*
Lange et al. (2001)	30 undergraduates	Cognitive Behavioral [a]	10 sessions, 7.5 h, 5 weeks	Distal; Computer (via website)	not reported	Anxiety, Depression, General Psych Distress,	1.03 (0.42)*
Lintvedt et al. (2013)	163 undergraduate and graduate students	Cognitive Behavioral [a]	5 modules, 8 weeks	Distal; Computer (via website)	not reported	Depression, SE Skills	0.53 (0.20)**
Maltby (2002)	75 undergraduates F/U: 54 undergraduates	Cognitive Behavioral (Anxiety Sensitivity) [a]	1 session, .75 h, 2 weeks F/U: 26.14	Both; Computer (via local program)	not reported	Anxiety, Depression, Health	0.16 (0.33) F/U: 0.22 (0.32)
		Psychoeducational (Education)	1 session, .75 h, 2 weeks F/U: 26.14	Both; Computer (via local program)	not reported	Anxiety, Depression, Health	0.36 (0.33) F/U: 0.48 (0.33)
McFall and Lillesand (1971)	33 undergraduates	Social Skills [a]	2 sessions, .67 h, 1 week	Study Site; Audiotape Player	not reported	SE Skills	0.84 (0.41)*
McFall and Marston (1970)	42 undergraduates	Social Skills [a]	4 sessions, 4 h, 2.5 weeks	Study Site; Audiotape Player	not reported	Anxiety, SE Skills, Self-perceptions	0.43 (0.32)
Mogoase et al. (2013)	42 undergraduates	Other (Concreteness Training)	7 sessions, 1.75 h, 1 week	Distal; Computer (via email)	100%	Depression, SE Skills, Self-perceptions	0.10 (0.23)
Orbach et al. (2007)	90 undergraduate and graduate students	Cognitive Behavioral [a]	6 modules, 3 h, 6 weeks	Distal; Computer (via website)	not reported	Anxiety, SE Skills, Self-perceptions	0.41 (0.26)
Penton-Voak et al. (2012)	80 undergraduates	Other (Emotion Perception Training)	4 sessions	Study Site; Computer (via local program)	not reported	Depression, General Psych Distress	0.10 (0.23)
Pless (2010)	141 undergraduates	Cognitive Behavioral [a]	6 modules, 15 weeks	Distal; Computer (via website)	26%	Anxiety	−0.08 (0.17)
Radhu et al. (2012)	58 undergraduates	Cognitive Behavioral [a]	13 modules, 12 weeks	Distal; Computer (via website)	not reported	Anxiety, Depression, SE Skills	0.10 (0.21)
Rose et al. (2013)	66 graduate/professional students	Cognitive Behavioral [a]	6 sessions, 4 h, 6 weeks	Study Site; Computer (via local program)	89%	Self-perceptions, Stress	0.40 (0.26)

In cases when a study presents more than one intervention, we also list the original researchers' unique terms for the intervention conditions. Follow-up period (F/U) sample size reflects the number of participants completing follow-up assessments. F/U duration reflects the number of weeks between post-intervention and follow-up assessment

[a] Skill-training intervention

[b] Determined to be 100 % because TDI delivered at a proctored study site for one session

*$p < .05$; **$p < .01$

outcomes. Indicated skill-training interventions yielded significant effects for seven of the nine outcome categories, including depression, anxiety, stress, health ($k=2$), self-perceptions, interpersonal relationships ($k=2$), and spirituality ($k=2$), but the latter effect was negative (ES = −1.10). Non-skill-training interventions only achieved significance for depression and interpersonal relationships ($k=1$) outcomes. Table 3 (footnote) also presents ES for each primary intervention strategy with $k>2$ (e.g., ACT, CBT, mindfulness, relaxation, social skills, online support groups, and psychoeducation).

Tests for Moderation

We assessed whether each of 15 variables was significantly related to outcomes for either the universal or indicated interventions: (1) school type, (2) experimental design, (3) primary type of technology, (4) level of available support, (5) nature of available support, (6) type of student, (7) type of control, (8) starting sample size, (9) percent attrition, (10) differential attrition, (11) duration (in hours), (12) ethnicity (percent non-Caucasian), (13) primary type of technology (old versus new), (14) publication status, and (15) dosage (completion percentage). For these analyses, we aggregated all outcomes to the intervention level for universal and indicated interventions separately. Mean ESs and CIs were compared for the dichotomous variables, and correlations were computed for the continuous variables to determine which variables were significantly related to effect size.

However, we could not test for moderation using the first three variables for universal or indicated interventions because there was not enough variability in them (e.g., 47 of the 48 interventions were randomized). For universal interventions, level and nature of support (variables 4 and 5) could not be examined due to lack of variability. Among indicated interventions, there was not enough variability in type of student or type of control (variables 6 and 7) to be tested as moderators. Among the 10 moderators tested for universal interventions and the 9 moderators tested for indicated interventions, only three emerged as significant: publication status for both universal and indicated interventions, level of available support for indicated interventions, and dosage for universal interventions.

Publication Status

Publication status was related to effect size for both types of prevention. Published universal interventions (ES = 0.26, CI = 0.15 to 0.37; $k=13$; $p<.001$) were associated with significantly higher effects compared to unpublished reports (ES = 0.09, CI = −0.06 to 0.23; $k=9$; $p=.231$). Similarly, published indicated interventions (ES = 0.46, CI = 0.34 to 0.57; $k=20$; $p<.001$) were associated with significantly greater effects compared to unpublished indicated interventions (ES = 0.07, CI = −0.14 to 0.28; $k=6$; $p=.523$). For both types of prevention, the mean ESs were statistically significant only for published reports.

Level of Available Support

Level of available support significantly moderated effects for indicated interventions, such that supported interventions (ES = 0.55, CI = 0.37 to 0.72; $k=10$; $p<.001$) yielded greater effects than self-administered indicated interventions (ES = 0.28, CI = 0.14 to 0.40; $k=16$; $p<.001$).

Dosage

Dosage significantly moderated effects for the 12 universal interventions that presented dosage data (see Table 2), $Q(1)=5.16$, $p=.023$, such that those with a higher percentage of intervention completers demonstrated better outcomes. Dosage did not moderate the outcomes for the eight indicated studies that presented data, $Q(1)=1.37$, $p=.242$.

Effectiveness at Follow-up

Only 3 of the 22 universal interventions assessed outcomes at any follow-up period (range = 13 to 52 weeks; median = 35 weeks; $M=33.41$; $SD=19.65$). Averaged across all types of outcomes, universal interventions produced a significant positive effect at follow-up (ES = 0.30, CI = 0.06 to 0.54; $k=3$, $p=.015$) which was significantly higher than the ES obtained at post-intervention for these studies (ES = 0.13, CI = −0.05 to 0.31; $k=3$, $p=.154$).

Only 8 of the 26 indicated interventions assessed outcomes at any follow-up period (range = 2 to 26 weeks; median = 13 weeks; $M=14.24$; $SD=11.67$). These indicated interventions yielded a significant positive effect at follow-up (ES = 0.49, CI = 0.31 to 0.67; $k=8$, $p<.001$), which did not differ significantly from the mean post-intervention ES for these studies (ES = 0.41, CI = 0.25 to 0.58; $k=8$, $p<.001$).

Discussion

This is the first systematic review and meta-analysis of controlled outcome research on technology-delivered mental health interventions, targeting higher education students, that includes both published and unpublished investigations and evaluates results separately for universal and indicated programs. The following three sections: (a) discuss the primary results and their implications for universal and indicated programs, (b) place current findings within the context of previous research on preventive mental health programs, and (c)

Table 3 Intervention mean post effect sizes (Hedge's *g*, SE, confidence interval), within-group Q statistics, and I^2 values for interventions and outcome categories

		All outcomes combined	Depression	Anxiety	Stress	Gen psych distress	Health	Soc-emot skills	Self-perceptions	Interpersonal relationships	Spirituality
Universal prevention											
Skill training	ES (SE)	0.21 (0.05)**	0.20 (0.00)**	0.25 (0.06)**	0.34 (0.10)**	−0.05 (0.08)	0.21 (0.30)	0.17 (0.09)	0.04 (0.09)	0.26 (0.11)*	–
	CI	0.11–0.31	0.08–0.31	0.15–0.36	0.15–0.54	−0.20–0.11	−0.39–0.80	−0.00–0.33	−0.14–0.22	0.04–0.47	–
	k	17	9	12	5	8	1	7	7	5	–
	Q	10.51	14.38	13.24	25.45**	2.36	0.00	4.73	8.59	3.98	–
	I^2	0.00 %	44.35 %	16.93 %	84.28 %	0.00 %	0.00 %	0.00 %	30.15 %	0.00 %	–
Not skill training	ES (SE)	0.15 (0.09)	0.17 (0.21)	0.94 (0.22)**	–	0.12 (0.10)	0.34 (0.15)*	0.11 (0.12)	−0.02 (0.10)	–	−0.07 (0.21)
	CI	−0.03–0.33	−0.24–0.58	0.51–1.37	–	−0.06–0.31	0.04–0.63	−0.13–0.35	−0.22–0.18	–	−0.49–0.35
	k	5	1	1	–	4	3	1	4	–	2
	Q	4.41	0.00	0.00	–	7.71	1.94	0.00	4.83	–	0.00
	I^2	9.37 %	0.00 %	0.00 %	–	61.07 %	0.00 %	0.00 %	37.85 %	–	0.00 %
Indicated prevention											
Skill training	ES (SE)	0.39 (0.06)**	0.42 (0.08)**	0.30 (0.07)**	0.81 (0.08)**	0.18 (0.18)	0.68 (0.15)**	0.41 (0.07)**	0.47 (0.10)**	1.17 (0.07)**	−1.10 (0.15)**
	CI	0.29–0.50	0.27–0.57	0.17–0.43	0.64–0.97	−0.18–0.54	0.40–0.97	0.27–0.55	0.27–0.68	0.86–1.49	−1.40–−.80
	k	20	11	15	6	3	2	14	6	2	2
	Q	25.13	16.72	16.89	94.84**	2.71	7.13**	22.26	3.66	11.18**	13.04*
	I^2	24.40 %	40.18 %	17.11 %	94.73 %	26.13 %	85.98 %	41.59 %	0.00 %	91.06 %	92.33 %
Not skill training	ES (SE)	0.25 (0.12)*	0.26 (0.12)*	0.36 (0.19)	0.04 (0.32)	0.28 (0.16)	0.09 (0.33)	0.33 (0.19)	−0.03 (0.21)	1.66 (0.40)**	0.17 (0.29)
	CI	0.01–0.49	0.02–0.50	−0.02–0.74	−0.59–0.67	−0.03–0.59	−0.55–0.74	−0.04–0.70	−0.45–0.39	0.88–2.44	−0.40–0.73
	k	6	6	3	1	3	1	3	2	1	1
	Q	5.27	9.57	3.71	0.00	0.42	0.00	2.05	4.63*	0.00	0.00
	I^2	5.08 %	47.77 %	46.06 %	0.00 %	0.00 %	0.00 %	2.62 %	78.42 %	0.00 %	0.00 %

k denotes the number of intervention in each cell. *Q* refers to within-group heterogeneity. Specific universal intervention types yielded the following effects: CBT (ES = 0.23**, CI = 0.09 to 0.37, *k* = 7), mindfulness (ES = 0.28, CI = −0.24 to 0.80, *k* = 1), social skills (ES = 0.22, CI = −0.01 to 0.45, *k* = 4), relaxation (ES = 0.26, CI = −0.16 to 0.67, *k* = 2), online support group (ES = 0.26, CI = −0.41 to 0.94, *k* = 1), ACT (ES = 0.07, CI = −0.18 to 0.31, *k* = 2), and psychoeducation (ES = −0.16, CI = −0.58 to 0.26, *k* = 2). Specific indicated intervention types yielded the following effects: CBT (ES = 0.39**, CI = 0.27 to 0.50, *k* = 17), mindfulness (ES = 0.33, CI = −0.18 to 0.83, *k* = 1), social skills (ES = 0.59*, CI = 0.10 to 1.07, *k* = 2), online support group (ES = 1.06**, CI = 0.29 to 1.83, *k* = 1), and psychoeducation (ES = 0.29, CI = −0.14 to 0.71, *k* = 2)

*$p < .05$; **$p < .01$

indicate some limitations in the current review and offer suggestions for how to improve future research.

Universal Interventions

Current data suggest that universal TDIs are effective for higher education students. Moreover, their ability to reduce symptoms related to depression, anxiety, and stress has potentially important implications, as these are some of the most common adjustment problems of this population. Furthermore, problems in these areas can interfere not only with students' personal and social adjustment but also with their academic performance and rates of school completion (American College Health Association 2014; Center for Behavioral Health Statistics and Quality 2014; Eisenberg et al. 2009). The success of universal TDIs in significantly improving students' interpersonal relationships also enhances their potential value. It also is notable that almost all (21 of 22) of the universal TDIs were self-administered, which suggests that they could easily be implemented on college campuses.

Indicated Interventions

Effectiveness of Indicated Versus Universal TDIs

As we hypothesized, indicated TDIs were significantly more effective than their universal counterparts, a finding that is likely due to the higher symptom level of students who participate in indicated interventions. This finding is consistent with previous meta-analyses of preventive FTF interventions for youth and adults (e.g., Stice et al. 2006; Wilson et al. 2001) and indicates the importance of examining the impact of universal and indicated programs separately. Compared to universal interventions, indicated TDIs also achieved significant positive effects in two additional outcome categories (health and self-perceptions, in addition to depression, anxiety, stress, and interpersonal relationships). Moreover, in two of three categories in which both types of preventive interventions achieved significant effects (depression and stress), indicated programs achieved mean ESs that were over twice the magnitude of universal interventions. These findings underscore the importance of analyzing the results of universal and indicated programs separately to obtain a better picture of the impact of these two types of preventive intervention on different types of outcomes.

Amount and Nature of Support

Supported indicated TDIs were significantly more effective than self-administered indicated TDIs, although we were unable to clarify how the amount or nature of support played a role. The value of support for indicated preventive interventions is consistent with data from adult treatment studies suggesting that those with clinical-level problems receive more benefit from supported than self-administered TDIs (Andersson and Cuijpers 2009; Mohr et al. 2011; Newman et al. 2011; Spek et al. 2007). Because almost all the universal interventions we reviewed were self-administered, the issue of how support may affect outcomes for these interventions merits further study.

Common Findings Across Universal and Indicated Interventions

There are two important common findings across the two types of preventive approaches: (a) the effectiveness of skill-training programs and (b) the low rates of attrition for participants.

Skill Training

Skill-training interventions demonstrated a stronger pattern of effects compared to approaches that did not focus on skills. Differences between skill-training and non-skill-training interventions did not reach statistical significance, and we were not able to examine specific intervention components that approximate supervised skills practice, a moderator of outcomes in a meta-analysis of FTF interventions with higher education students (Conley et al. 2015). Nevertheless, the current significant positive findings for both universal and indicated skill-training interventions are consistent with a growing literature base in prevention that indicates that helping participants learn and apply new skills promotes adjustment and reduces problems (Conley et al. 2015; Durlak 1997). Collectively, these findings recall Allensworth's (1993) statement from over 20 years ago: "Acquisition of basic skills at appropriate ages appears to be a primary component of all prevention" (p. 17).

Attrition

Attrition has been a problem in prior research on TDIs (Bee et al. 2008; Christensen et al. 2009; Richards and Richardson 2012), particularly for self-administered TDIs, which constituted the bulk of interventions (95.5 % of universal, 61.5 % of indicated) reviewed here. Yet, in the current review, the rates of both overall sample attrition (18 % universal, 15 % indicated) and differential between intervention and control groups (6 % universal, 7 % indicated) were modest. The ability of these interventions to retain most higher education participants is encouraging.

Putting Current Findings into Context

Magnitude of Effects

The magnitude of effects found for universal interventions in the three outcome areas of depression, anxiety, and stress is not small. Cohen's (1988) conventions for judging effect magnitudes as small, medium, or large effects are not applicable for universal prevention. Rather, the magnitude of effects should be interpreted against empirical standards obtained in similar research areas. Mean ESs in the 0.20s to mid-0.30s achieved in the current meta-analysis are comparable to those reported for universal FTF interventions for school-age youth (age 5 through 18) (see Table 5 in Durlak et al. 2011).

Comparisons with Other Meta-Analyses

It is possible to compare the effects obtained in the current review with those reported in two recent meta-analyses of FTF universal (Conley et al. 2015) and indicated interventions (Shapiro et al. 2015) for higher education students. The study-level mean ES for universal TDIs in the current review (0.21; CI 0.11 to 0.31) is significantly lower and less than half the magnitude than that for FTF interventions (0.45; CI 0.39 to 0.52; Conley et al. 2015). Furthermore, whereas universal FTF interventions achieved significant results for all six comparable outcomes listed in Table 3, TDIs in the current review only achieved significance for the first three (depression, anxiety, and stress).

Similarly, the mean ES for the 28 indicated skill-training TDIs in the current review (0.39; CI 0.29 to 0.50) is significantly lower than that obtained by indicated skill-training FTF interventions in another meta-analysis (0.61, CI = 0.56 to 0.66; Shapiro et al. 2015), and TDIs achieved significance for only five categories (depression, anxiety, stress, self-perceptions, interpersonal relationships), whereas FTF interventions did for all seven. In three comparable outcome categories (i.e., depression, anxiety, general psychological distress), the mean effects for indicated FTF interventions is 1.67 to 2.07 times higher than the respective ESs for TDIs (0.84 vs 0.42, 0.62 vs 0.30, and 0.30 vs 0.18, respectively). On the other hand, for stress outcomes, TDIs achieved an effect that is 1.65 times higher compared to FTF interventions (0.81 vs 0.49).

In summary, although universal and indicated TDIs achieve some positive effects, overall these interventions do not currently appear as effective as FTF interventions for higher education students. However, the potential benefits of TDIs in terms of reaching more participants, reducing stigma, and being cost-effective also should be considered when evaluating their overall impact and value.

Limitations and Future Research Directions

There are several limitations in the current review that qualify our generally optimistic conclusions and suggest fruitful directions for further research. First, dividing studies according to different variables resulted in several small cell sizes, which limited the types of comparisons we could make and renders our conclusions tentative. For example, there were few studies that did not target skills, so conclusions about the overall and relative effectiveness of skill-training interventions compared to other types of interventions await further confirmation. Furthermore, dividing studies according to six major outcome categories also resulted in few investigations in several cases. As a result, our conclusions about which dimensions of adjustment are significantly affected by both types of prevention might be modified as additional research appears. Further, missing data limited the power to detect the influence of some potentially important moderators, such as sample ethnicity and intervention duration, and the low amount of heterogeneity among study effects limited our ability to determine the impact of other potentially important variables.

Second, Danaher and colleagues (2015) have noted that TDIs for adults often are a "black box" lacking many pertinent details about the process and critical intervention features, and the same applies to our study sample. Several authors (e.g., Barak et al. 2008; Jones 2014; Proudfoot et al. 2011) have offered suggestions about what details should be provided in TDIs, and the following discussion integrates their suggestions with our own, focusing on three main categories: (a) adequate reporting of study details, (b) issues germane to various design, assessment, and analytic analyses, and (c) issues regarding program impact and implementation.

Adequate Reporting of Study Details

In terms of samples, authors should describe the diversity of their participants on various characteristics (e.g., age, gender, ethnicity) and collect data on variables that might influence program impact (e.g., comfort level with technology, expectations concerning outcomes). Studies should also specify the intervention's presumed active ingredients, how these important components are delivered, what specific effects are expected, and how these effects are assessed. For example, skill-training interventions should detail what exact skills are being targeted, how proficiency in these skills is to be attained, and how acquisition of these skills is measured. We found that only seven universal and six indicated interventions assessed participants' social and emotional skills, so we could not conclude that skill development was the active agent of change.

In the current sample, only 3 of 22 universal and 12 of 26 indicated interventions were available for public inspection, either through an appendix or a website. We recommend that researchers place their complete intervention online or provide

access to the intervention on request. If the intervention is not in the public domain due to proprietary reasons, authors should consider limited access for research purposes. Without information on the critical details and features of TDIs, our understanding of how they do or do not produce desirable effects will remain greatly limited.

Design, Assessment, and Analytic Issues

We found that most intervention strategies (e.g., CBT, mindfulness, relaxation, social skills, online support groups) yielded effects in the 0.20s to 0.30s, with some higher effects among indicated interventions, and that both universal and indicated TDIs were effective when delivered using both older and newer technologies (e.g., DVDs and VCRs versus computers and mobile phones). Not only are more studies needed to compare the impact of different intervention strategies on the same device, but also investigators should assess if some intervention strategies are more effective depending on their method of delivery (e.g., mobile phones, computers, virtual reality programs).

Almost all of the outcome data in the current review were based on self-reports. Although they are more challenging to collect, researchers can more objectively discern changes over time with behavioral tests, school records (e.g., grades, retention), diagnostic interviews, biosensors that collect physiological data on stress levels, and independent ratings from objective observers, peers, teachers, or parents (e.g., McFall and Marston 1970). It also would be helpful to collect consumers' ratings of the intervention's usability, likability, and practical relevance.

Regarding analytic issues, researchers should attempt to limit missing data and to follow up with all participants originally assigned to conditions regardless of intervention completion. There are a variety of methodological and analytic procedures, including strategies to deal with missing outcome data, that can be used to reduce selection bias and confounding, and improve external validity (see Alshurafa et al. 2012). However, it is important that researchers use an appropriate statistical strategy for dealing with missing data and exercise caution about violating assumptions about data missing at random (see Alshurafa et al. 2012; Armijo-Olivo et al. 2009).

Although in most TDIs participants proceed through the program on an individual basis, those involving group administration of some kind, such as online support groups, should use analytic strategies that account for nested data. Subgroup analyses also should be conducted whenever possible, to discern which individuals may profit more or less from intervention, although researchers should be cautious about the generalizability of the findings in the absence of representative samples and replication across studies. The results of the few studies that followed participants over time were encouraging in the sense that results either increased (for universal studies) or remained the same (for indicated studies) over follow-up periods averaging 33 and 14 weeks, respectively. However, more follow-up studies are needed.

Finally, we found a substantial effect for publication status as the mean ESs for published reports were 2.9 times higher for universal studies and 6.6 times higher for indicated prevention, and in each case, only published reports yielded significant effects. Unpublished reports should be included routinely in reviews so as not to overestimate the impact of intervention.

Program Impact and Implementation

TDIs are frequently discussed in terms of their potential for reaching many more participants than FTF programs, involving those who otherwise would not receive services, and being more cost-effective (Newman et al. 2011; Proudfoot 2004; Tate and Zabinski 2004), but more research is needed on these topics. Sample sizes in the current review, compared to those in meta-analyses of comparable universal and indicated FTF interventions, are 1.42 to 2.51 times higher (Conley et al. 2015; Shapiro et al. 2015), suggesting the potential for greater population reach for TDIs (also see Murray 2012). To test whether TDIs can involve those who otherwise would not participate in FTF programs, research should compare different methods of describing and promoting TDIs and examine who among the eligible target population becomes involved in interventions.

One of the limitations of implementing intervention programs for higher education students is that students report barriers to seeking out FTF mental health services, which leads to low rates of care seeking (Eisenberg et al. 2011). More information is needed on whether TDIs improve help-seeking and whether there may be additional ways to engage students in interventions. Further, female higher education students are known to use FTF mental health services more so than their male peers do (Eisenberg et al. 2011), and 70 % of the participants in our review were female, so data are needed on how well TDIs attract males. Also, more research on how TDIs can be tailored to appeal more effectively to different ethnic groups is needed. Finally, several reports consisted of interventions that previously had been used with adult clinical and community samples, so it would be useful to learn if modifying some interventions to be more attuned to the needs and lifestyles of higher education students could improve impact. Future research on the reach and cost-effectiveness of different TDIs would reveal ways to apply them for maximal impact.

The level of achieved implementation often influences program outcomes (Durlak and Dupre 2008); monitoring the level of attained implementation and relating this level to program outcomes have been added to the criteria for determining the evidence base for prevention programs (Gottfredson et al.

2015). For FTF interventions, the most commonly researched aspects of implementation have been fidelity and dosage, but for TDIs we recommend a focus on assessing both dosage and engagement (sometimes called participant responsiveness), and relating these components to adherence. Whereas dosage reflects how much of the intervention was completed, it is not the same as adherence, which involves the extent to which participants apply the recommendations or guidance offered in the intervention to their daily lives. Dosage also is not the same as engagement—the extent to which participants interact with the intervention in a purposeful, attentive, or meaningful way—because participants can complete modules or sessions without becoming genuinely interested in or involved with the material; that is, they can merely go through the motions. As we envision it, engagement is similar to the concept of alliance in FTF interventions, in terms of the extent to which participants have formed any attachment to or confidence in the intervention.

It is important to assess dosage, engagement with, and adherence to TDIs separately. Whereas researchers should employ objective means to monitor dosage (e.g., tracking progress through modules, content of postings) and determine how much of the intervention has been completed, assessing engagement and adherence is probably better done through subjective self-reports. Using Likert scales, engagement can be assessed by asking participants to rate the intervention in terms of how useful, helpful, interesting, or relevant it was. To assess adherence, participants could similarly report on how often they completed homework and followed the intervention's recommendations for practicing and applying newly learned information and skills in their daily lives. These assessments were rare and variable in the current review, but future research can assess them more thoroughly and consistently, to determine how these constructs are related to each other and to outcomes. Future research also should investigate the mechanisms and benefits of *supportive accountability* strategies in TDIs, whereby support from paraprofessionals or even peers might enhance participant goal setting, expectations, accountability, and motivation, and thus improve intervention engagement, adherence, and outcomes (Mohr et al. 2011).

Concluding Comments

Our conclusions about the impact of universal and indicated preventive TDIs for higher education students are positive but qualified by the considerations we have discussed. The overall fundamental question that needs to be answered regarding TDIs is similar to that for any group of potentially helpful interventions: What types of interventions, containing what components, delivered using which technological devices, are most effective and cost-effective for what target populations and subgroups in achieving what types of immediate and long-term benefits? Furthermore, how do the relative advantages and limitations of TDIs compare to FTF approaches? It will take a series of studies addressing various relevant variables before different aspects of these two questions can be answered satisfactorily.

Acknowledgments Special thanks to the many research assistants who provided valuable contributions to this project.

Compliance with Ethical Standards

Funding This research was supported, in part, by an internal research grant from Loyola University Chicago.

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article is a meta-analysis of secondary data collected by other researchers and does not require ethical consent from the original study participants.

Informed Consent This meta-analysis involved no data collection directly from human subjects, and thus informed consent was not necessary.

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