

ehealth interventions targeting problematic alcohol use: A narrative review of effectiveness

Thesis

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Abstract

Background: Alcohol use causes a considerable burden on contemporary societies and individuals, with the WHO estimating as much as 5.9% of all deaths globally and 5.1% of the total burden of disease and injury is attributable to alcohol. Increasingly, interventions targeting the problematic use of alcohol are being developed that can be delivered over the internet (ehealth) and mobile phones (mhealth). Although this is a promising development, little is known about their effectiveness, with experts calling for an oversight of scientifically grounded and validated interventions. However, recent reviews on the effectiveness of ehealth interventions targeting alcohol use are lacking and to-date, no comprehensive review has been conducted that reviews the evidence of diverse ehealth interventions for different population subgroups. The present study provides a narrative review of ehealth intervention effectiveness targeting problematic alcohol use.

Methods: A systematic search was conducted in PubMed in December 2016 for English abstracts published in the last 5 years. Search terms were relating to 1) ehealth, mhealth, internet, online, 2) alcohol*, drinking (where * denotes a wildcard), 3) RCT, randomized controlled trial. An additional search was conducted combining the above with 4) self-management, self-care, general practitioner, GP, primary care. Forward and backward citation tracking was performed to identify additional literature. Inclusion criteria were 1) the primary intervention was delivered via the internet or a mobile phone, 2) The primary outcome measure relates to alcohol consumption, 3) the intervention was a randomized controlled trial of an alcohol-related screening, assessment, or intervention.

Results: After a selection process, 24 articles were included in the review, reporting 22 unique study designs targeting adolescents (N=16) or adults (N=8) with problematic alcohol consumption (N=22). Most studies reported the effectiveness of web-based (N=20) brief psychological interventions (N=16). 11/16 studies targeting adolescents found a significant difference between intervention and assessment only controls. Most were brief interventions combining a motivational interviewing (MI) approach with personalized normative feedback (PNF)(N=7). Other interventions were based on decisional balance therapy, cognitive bias modification or cognitive behavioural therapy. One study targeting adolescents with a low education background was not effective, while the same intervention targeting students was. All adult studies targeted problematic drinkers, aiming to reduce consumption (N=5), achieve and maintain abstinence (N=2) or increase medication adherence (N=1).

Discussion: The present study showed that extensive (brief) interventions were generally more effective than brief interventions adopting single therapeutic approaches, e.g. only motivational interviewing or only normative feedback. Few (N=2/8) of the interventions targeting adults were found effective, although four out of eight found reduced consumption in all groups. This may be explained by the studies' design, since ehealth interventions were provided on top of treatment as usual, rather than compared with treatment as usual. In order to determine whether ehealth is equal or more effective than care as usual, future RCTs should compare stand-alone interventions with treatment as usual. Here, ethical considerations can be overcome by including non-treatment seeking participants identified via screening. Most participants in adult studies were self-selected problem drinkers actively looking for treatment. In line with theoretical models on change such as the Transtheoretical model, high initial motivation to change is associated with higher treatment effectiveness. High attrition rates were observed, particularly among heavier drinkers, lower educated individuals, males, and people with low treatment readiness. This corresponds to the literature on alcohol treatment.

Conclusion: More extensive interventions, including decisional balance feedback and brief motivational interventions complemented with either normative feedback, prototype alteration or cue reminder strategies, were found to be most effective. Effects are generally small and persist on the short- to medium-term. They may still result in substantial health gains considering they can reach many people that would otherwise not seek help. Ehealth can result in substantial health gains since they offer a low threshold alternative that people can conduct anonymously, in their own time, on their own pace and on a location that suits them best. Despite large between-study differences, it can be concluded that ehealth interventions are more effective than no intervention. There was limited evidence that digital interventions are equal to or more effective than care as usual.

Keywords: ehealth, mhealth, alcohol, effectiveness, intervention, review

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Abbreviations:

| | |
|-----------|--------------------------------------------------------------------|
| AUD | Alcohol Use Disorder |
| AUDIT(-C) | Alcohol Use Disorder Identification Test (Consumption subscale) |
| BAC | Blood Alcohol Concentration |
| BI | Brief intervention |
| CBM | Cognitive Bias Modification |
| CBT | Cognitive Behavioural Therapy |
| DBT | Decisional Balance Therapy |
| DDD | Drinks per Drinking Days |
| EMA | Ecological Momentary Assessment |
| HED | Heavy Episodic Drinking ('Binge drinking') |
| LHV | The Dutch General Practitioners Association |
| MI | Motivational Interviewing |
| NHG | The Dutch College of General Practitioners |
| PAU | Problematic Alcohol Use |
| PDA | Percent Days Abstinent |
| PNF | Personalized Normative Feedback |
| RDD | Risky drinking days (days with HED) |
| SMS | Short Message Service |
| RCT | Randomized Controlled Trial |
| WAC | Weekly Alcohol Consumption |
| WHO | World Health Organization |

1. Introduction:

Globally a large burden is associated with the consumption of alcohol. The WHO estimates 5.9% of all deaths and 5.1% of the global burden of disease and injury are attributable to alcohol. Alcohol affects younger age groups disproportionately, with approximately 25% of total deaths of 20-39 year olds being attributable to alcohol (WHO Factsheet, 2015). In total, over 200 disease and injury conditions are caused by alcohol consumption (WHO factsheet, 2015). This includes physical, mental and behavioural disorders such as alcohol dependence, liver cirrhosis, multiple cancers, depression and problems at work. Injuries resulting from alcohol are both unintentional and intentional, such as those caused by (road traffic) accidents and violence (WHO, 2015). In 2011, the costs of problematic alcohol consumption for the Dutch society are estimated at 3.7 billion euro (Boomsma *et al.*, 2014), which includes costs for addiction- and healthcare, costs due to productivity loss and criminal offenses. Over 80% of the Dutch population between 20 and 65 years of age consumed alcohol in 2015 (Trimbos, 2016), with the highest consumption for those between 20 and 30 years of age, equalling 87.2%. The estimated prevalence of problematic alcohol use is 7-11% of the Dutch population, which comes down to around one million people (Franx & van Splunteren, 2014). A typical general practice in the Netherlands (+ 2150 patients) has an estimated 100 to 150 patients with problematic alcohol consumption, of whom only a minority is known as such by the GP (Boomsma, 2015).

The Dutch College of General Practitioners (NHG) has a guideline on the problematic use of alcohol ('NHG-Standaard Problematisch alcoholgebruik'; Boomsma *et al.*, 2014). The guideline is adopted from the DSM-5, which has formally replaced the DSM-IV in the Netherlands from January 1st, 2017 (Schippers, 2016). The problematic use of alcohol - also referred to as problematic alcohol consumption (PAC) - is "the drinking pattern that leads to physical complaints and/or psychological or social problems and prevents that existing problems are adequately addressed" (Boomsma *et al.*, 2016, P.2). An Alcohol Use Disorder is the problematic use of alcohol that meets the DSM-5 criteria for Alcohol Use Disorders, with mild, moderate and severe sub-classifications (Boomsma *et al.*, 2014; NIAAA, year). Furthermore, the guideline makes a distinction between youth and adults with problematic alcohol use. For youth, the problematic use of alcohol generally exists for a shorter period, and the pattern of drinking (e.g. binge-drinking) and the perpetuating factors (e.g. peer pressure, social norms) are different than that of adults. Tackling problematic alcohol use is important considering the severe impact on the health and wellbeing of individuals and society at large. Health professionals play an important role in reducing the harmful use of alcohol by monitoring the consumption thereof in their patients, providing brief interventions, counselling and pharmacotherapy in identified cases of problematic alcohol use and alcohol use disorders (Babor *et al.*, 2010; WHO, 2015, Moyer *et al.*, 2013).

There has been an increase in internet- and smartphone access in contemporary societies, as well as an increasing number of people that use this to search for health information. In the Netherlands, 96% of the population has a smartphone, and 80% uses their smartphone to search for health information (Health Consumer Powerhouse, 2017). Since only a small percentage of problematic drinkers seek help for their problems, ehealth also has the potential to reach large numbers of peoples that would otherwise not seek help (Meredith, Alessi & Petry, 2015). eHealth may offer a low threshold alternative, which can be performed anonymously, at people's own pace, in their own time, and on a location that suits them best (Cunningham, Selby, Kypri, & Humphreys, 2006; Vernon, 2010; Riper *et al.*, 2011). A wide array of definitions on eHealth exist, showing considerable overlap. The WHO defines eHealth broadly as *the use of information and communication technologies (ICT) for Health*. Similarly, the Dutch National HealthCare Institute (CVZ) defines eHealth as: "the use of ICT – and internet technology in particular – to support or improve health and healthcare" (Rijen, de Lint & Ottes, 2002). It can be derived from these broad definitions that eHealth may serve different

purposes and target different user groups. Additionally, it becomes clear that ehealth can be deployed both with and without involvement of healthcare professionals. Consequently, the question arises whether ehealth can complement or (partially) replace existing face-to-face care. Important to note is that many (ehealth) interventions exist, with different theoretical underpinnings. These different intervention types are more elaborately discussed in the contextual background.

Despite the promises of ehealth interventions and the increasing availability, it seems that both HCPs and patients are reluctant to use ehealth (Krijgsman & Wolterink, 2012; LHV & NHG, 2012; van Duivenbooden, 2015). An important factor explaining this reluctance is an apparent lack of knowledge about the quality and effectiveness of the interventions (Krijgsman & Wolterink, 2012; LHV & NHG, 2012), which also poses a threat to its further development (Krijgsman & Wolterink, 2012; Krijgsman *et al.*, 2015; Franx & van Splunteren, 2015). Evidence lags behind the implementation and there is a discrepancy between expectations and evidence (LHV & NHG, 2012; McKibbin, 2011). Therefore, the National Association for General practitioners (LHV) and the NHG have prioritized the substantiation of (cost)effectiveness of increased digitalization of care on the innovation agenda (LHV & NHG, 2012). Here, the importance of ehealth based on scientifically validated methods is highlighted, as well as a need for an oversight of high quality interventions (LHV & NHG, 2012) and continuous evaluation of ehealth interventions (Catwell & Sheikh, 2009; Riper *et al.*, 2011; Sundström *et al.*, 2016). It is further unclear which interventions offer added value over existing care, and if so, for which groups and under which circumstances. Randomized Controlled Trials (RCTs) are considered the golden standard in the scientific realm to show effectiveness of interventions, since other variables are equal between groups and any difference in outcome can be attributed to the intervention (Stolberg, Norman & Trop, 2004). However, as far as known, no review has provided a comprehensive overview of the effectiveness of ehealth interventions. This study adds to the scientific body of knowledge by providing a comprehensive overview of the effectiveness of ehealth interventions that may complement or (partially) replace conventional care at general practices regarding the problematic use of alcohol. This is done by reviewing the scientific literature for evidence of effectiveness of ehealth interventions in light of the problematic use of alcohol. This is done by answering the following research question:

What evidence is there for ehealth interventions to complement general practices in light of the problematic use of alcohol?

Two sub-questions have been derived from this research question, which are based on the control group chosen in the RCT design. Firstly, the question arises whether digital intervention are superior to no intervention. This may be particularly interesting for those assessing interventions through own interest and motivation, and for those that would otherwise not seek help. The other sub-question explores whether digital interventions are equally or more effective than care as usual. If so, this would indicate that ehealth may actually partially replace existing care. For both questions, if effective, the question arises for which groups and under which circumstances interventions are effective.

2. Background

In this section, the different intervention types and their theoretical underpinning are briefly explained. First, brief psychological interventions are described, which are motivational interviewing and personalized normative feedback. Thereafter, more extensive intervention types are explained, including cognitive behavioural therapy, cognitive bias modification and behavioural self-control training.

Brief psychological interventions

Brief interventions consist of one or multiple interventions ranging from 5 to 30 minutes within a limited number of months. Patients are often not aware of the problematic aspect of alcohol usage and not motivated to change. The main aim of brief interventions is to guide patient-directed behavioural change (Franx & van Splunteren, 2015). Often, brief interventions combine one or multiple motivational interviewing techniques. Frequently deployed brief interventions with proven effectiveness in face-to-face consultations are motivational interviewing and personalized normative feedback (Moyer, Finney, Swearingen, Vergun, 2002; Kaner *et al.*, 2007; Riper *et al.* 2011; Boomsma *et al.*, 2014; Franx & van Splunteren, 2014), which can be provided separately and in combination.

Motivational interviewing focuses on making explicit and increasing motivation to change, as well as decreasing the patient's ambivalence towards changing behaviour (Boomsma *et al.*, 2014; Franx & van Splunteren, 2014). This may include (Franx & van Splunteren, 2014):

- Personalized feedback about excessive use of alcohol
- Providing advice and options for behaviour change
- Discussing possibilities and opportunities to change alcohol consumption
- Choice to drink less or stop drinking and discussing high-risk situations.
- Providing estimated blood alcohol concentration levels and caloric value of consumption
- Estimates of expenditure on alcohol

The decisional balance method is one method of resolving the ambivalence towards behavioural change, thereby increasing motivation to change (Collins, Kirouac, Lewis, Witkiewitz, Carey, 2014; Foster, Neighbors & Pai, 2015). Collins *et al.* (2014) explain that decisional balance is about evaluating the perceived advantages (pros) and disadvantages (cons) of engaging in certain behaviour and its alternatives.

Personalized normative feedback (PNF) is a type of brief intervention based on a social norms approach. Research has shown that students consistently misperceive alcohol consumption levels of their peers (Lewis & Neighbors, 2006; Moreira, Oskrochi & Foxcroft, 2012). College students not only overestimate peer drinking levels, but this misperception is also associated as a causal factor of heavy drinking (Perkins & Berkowitz, 1986; Lewis & Neighbors, 2006). Lewins & Neighbors (2006) explain that PNF aims to correct this misperception by comparing an individual's alcohol consumption with that of their cohort or peer group. Furthermore, it becomes clear that providing individual *personalized* feedback is likely to have a greater impact because of its salient and explicit nature in revealing discrepancies between personal drinking behaviour, perceived peer drinking behaviour and actual peer drinking behaviour.

Other interventions

Beside these basic interventions, more extended forms of ehealth interventions targeting problematic alcohol consumption are based on cognitive behavioural therapy, cognitive bias modification, behavioural self-control, self-help groups, pbrief psychodynamic therapy, interpersonal therapy, or combinations thereof (Kalden, Carroll, Donovan, Cooney, Monti, Abrams, 1992; Hester, 2003; Riper *et al.*, 2011).

Cognitive behavioural therapy (CBT) refers to a type of psychological intervention that, together with motivational interviewing, has the highest effectiveness (Franx & van Splunteren, 2014). CBT combines cognitive therapy and behavioural therapy, which involves influencing behaviour and simultaneously influencing (negative) thinking about this behaviour (Franx & van Splunteren). Central to CBT is identification of risk situations and the development of effective coping strategies.

Cognitive bias modification (CBM) is a type of psychological therapy that is based on modifying cognitive processes, aiming to train the brain to break through learnt thought patterns, or 'biases'. CBM reflects a dual-process model between impulsivity and reflectivity (Wiers, Gladwin, Hofmann, Salemink & Ridderinkhof, 2013). Emotional and motivational processes are important in the impulsive system, while knowledge of long-term consequences is important in the reflective system (Wiers *et al.*, 2013). According to Wiers *et al.* (2015) in addition, the impulsive processes gain control over behaviour, even when the long-term consequences of this behaviour are known. CBM aims to either strengthen the control processes or to change biases in attention and action tendencies. Two main varieties of CBM exist, which are attention control training (aimed at increasing control over distraction by alcohol) and approach bias-re training (aiming to modify a person's approach bias for alcohol-related stimuli).

Behavioural self-control training: This type of intervention is a multi-component behavioural intervention, aimed to teach skills that enable controlled drinking as a treatment goal (Walters, 2000; Saladin & Ana, 2004). Typical behavioural elements included are goal setting, self-monitoring, managing consumption, rewarding the attainment of goals, identification of triggers for excessive drinking, learning alternative coping skills.

Self-help groups: Self-help groups are designed for people that want to help themselves and each other with their problematic alcohol consumption (Franx & van Splunteren, 2014). The most well-known self-help group is Alcoholics Anonymous (AA, Anonieme Alcoholisten).

Prototype alteration: prototypes refer to the mental image of a typical person engaging in certain behaviour. (...) Prototypes can incorporate core values that individuals desire (or avoid). Altering the perception of prototypes can be used as a strategy to cultivate behaviour change.

Cue reminders. Can help in changing and maintaining behaviour because cue reminders can help people remember the content of interventions or their personal goals.

Medication: Pharmacological therapy for the problematic use of alcohol is divided in the combatting of withdrawal symptoms and relapse prevention (Franx & van Splunteren, 2014). Withdrawal symptoms are generally not treated with medication. In severe cases, patients are referred to centres for addiction care.

Monitoring and relapse prevention: Periodical monitoring of the treatment. Contact with the patient is maintained via follow-up consultations. Treatment evaluation takes place after a maximum of four months.

On top of the aforementioned therapies, several ehealth interventions were based on the I-CHANGE model. Also, one intervention was based on self-determination theory.

The I-CHANGE model - the Integrated Model for Explaining Motivational and Behavioral Change – is a psychosocial model developed by de Vries, Dijkstra & Kuhlman (1998). The model states that behaviours are determined by a person's motivation or intention to carry out a particular behavior. Actual behavior is the result of one's intentions and abilities. The model integrates the following theories: the Theory of Planned Behavior (Ajzen, 1991), Social Cognitive Theory (Bandura, 1986), the

Transtheoretical Model (Prochaska & DiClemente, 1983), the Health Belief Model (Janz & Becker, 1984), and goal setting theories.

Self-Determination Theory: Self-determination theory is concerned with the motivation behind people's choices without external influences or interference from others (Deci & Ryan, 2011), and focuses on the degree to which someone's behaviour is self-determined and self-motivated. It states that three needs are to be met that contribute to an individual's adaptive functioning: being perceived as competent, feeling related to others, and feeling internally motivated and not forced into certain actions (Gustafson *et al.*, 2014).

3. Methods

Here, the methods used for this review are described.

In their article, Collins & Fauser (2005) describe which review method to choose when summarizing evidence or knowledge. Accordingly, systematic reviews involve explicit and transparent methods that are clearly stated and reproducible. However, the primary problem is that, due to their narrow focus and prescribed methods, systematic reviews do not allow for comprehensive coverage. Narrative reviews adopt less explicit methods but do offer the possibility for broader coverage (Collins & Fauser, 2005). Since the present study aims to provide a comprehensive overview of interventions and considers the narrative thread important to offer practical recommendations, the narrative review design is preferred. Furthermore, the time available to write the review, the number of co-authors and the nature of the material found determine which review type is most appropriate (Pautasso, 2013). For the present study, the relatively limited amount of time and the single author call for a narrative rather than a systematic review.

Search strategy

In December 2016, a systematic search was performed to identify relevant studies in the English language published in the PubMed database in the last five years. Only studies published in the last 5 years were included, which was considered suitable as ehealth – particularly mobile health – is a relatively and rapidly evolving field. Furthermore, the restriction regarding recency mitigated the risk of including studies based on outdated technologies and was further desirable for practical and delineation purposes.

Preliminary searches were performed in order to become familiar with the topic and to identify relevant keywords and synonyms thereof. Subsequently, systematic searches were conducted in PubMed using the following key terms: 1) alcoholism, alcohol, sobriety, sober, 2) telemedicine, mhealth, mobile health, ehealth, web-based, smartphone, mobile device, and 3) randomized controlled trial, RCT, randomised controlled trial. On top of the primary syntax encompassing these terms, a secondary search was performed to identify additional literature specifically relating to primary care, general practices, and self-management. The syntaxes made use of free text articles as well as Medical Subject Headings (MeSH terms). [Tiab] was used to search through titles and abstracts, rather than complete articles. Boolean operators (AND, OR, NOT) were used to combine search terms. Furthermore, the asterisk (*), also known as the wildcard, was used for truncation purposes. The PubMed search syntaxes have been included in Appendix 1. To identify additional studies, the author manually searched through the reference lists of identified studies as well as through lists of articles citing identified articles (backward- and forward citation tracking, respectively). On top of the PubMed database, the review examined Google Scholar to identify additional studies.

Inclusion and exclusion criteria

This review included studies when they met the following criteria:

1. Intervention delivered and accessed on the internet or mobile phone
2. Primary outcome measure related to alcohol consumption
3. Randomized controlled trial of an alcohol-related screen, assessment or intervention

Additionally, several exclusion criteria were established, which are the following: studies written in another language than English, literature reviews, study protocols, feasibility and pilot studies, studies relating to military clinics, unpublished studies, non-peer-reviewed studies, studies conducted in developing countries and studies not published within the past 5 years. Developing

countries may benefit greatly from ehealth due to its capacity for broad reach, including populations that are traditionally underserved (Gibbons *et al.*, 2011; Chung & Hilton, 2014). However, the present study aims to determine whether ehealth interventions can complement or partially replace care for AUDs at (Dutch/Western) general practices, and therefore only includes studies conducted in high-income countries.

Study selection

A flowchart of the study search and selection process is depicted below in figure 1. The first syntax yielded 130 hits, the second syntax yielded an additional 60 studies. Additionally, 4 studies were identified through a comprehensive Google Scholar search. Forward- and backward citation tracking led to the identification of an additional 11 studies. After removal of duplicates (N=18), a total of 187 studies were screened on the basis of titles and abstracts, which led to the exclusion of 155 studies that were not meeting the inclusion criteria and thus were not relevant to the research aim. The full-text of 32 articles were assessed. Of two studies, no full text could be retrieved, and another six studies did not meet inclusion criteria after reading the full-text. Therefore, the final study selection in this review consists of 24 studies published between December 2011 and December 2016.

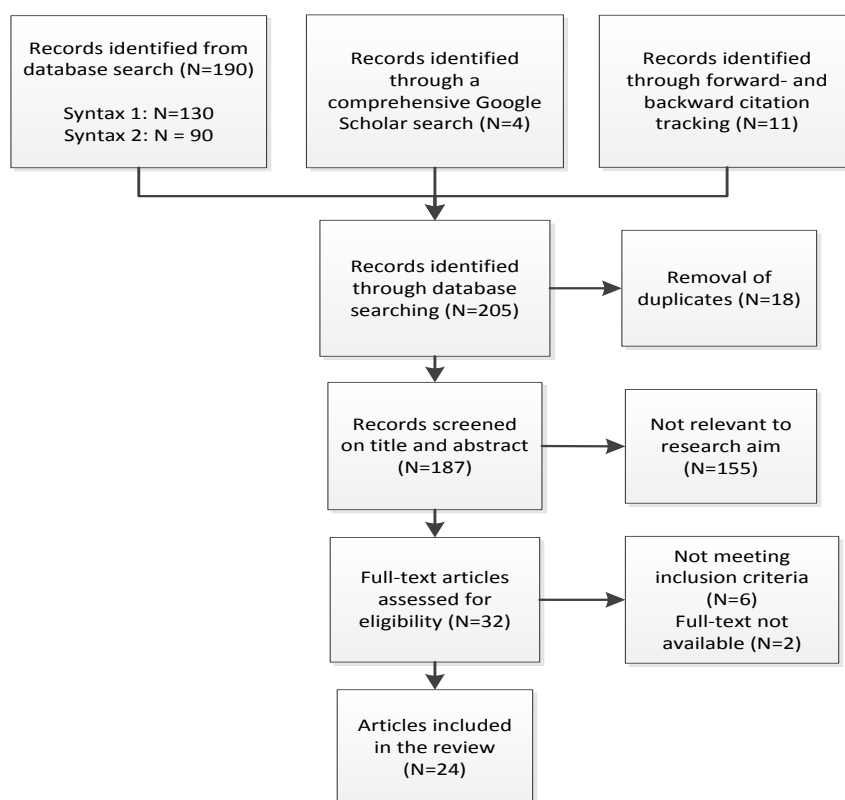


Figure 1: Flowchart of study search and selection

Data extraction and analysis

Relevant data was extracted from the included articles and summarized in an Excel sheet describing: Author, year of publication, country, sample (number of participants, target group), intervention characteristics (delivery mode, content, duration), study conditions, follow-up (including attrition rates), outcome measures, and a summary of findings. See Table 1. Careful reading and rereading of the articles was performed to minimize the possibility of missing relevant data. Data was structured based on target audience (i.e. adolescents or adults) and intervention types, as detailed in the background section. Subsequently, data was double-checked in order to ensure the findings of the review correspond with the original articles.

4. Results

The result section is used to describe the study characteristics as well as the effectiveness of interventions under review. A distinction is made between studies targeting adolescents and adults, as well as a distinction based on the intervention types as detailed in the contextual background. An overview of the study characteristics is given in Table 1.

The systematic search resulted in a final selection of 24 studies, describing the effectiveness of 22 randomized controlled trials. The difference is attributable to the fact that two of the studies were consecutive studies, with an original study and a separate article reporting the outcomes upon follow-up. These are the studies by Voogt *et al.* (2013b; 2014) and the studies by Hester *et al.* (2013) and Campbell *et al.* (2016). Studies were conducted in a diversity of countries, primarily from the USA (8), the Netherlands (6), Sweden (3), Switzerland (2), the United Kingdom (1), Germany (1), Canada (1) and New Zealand (1). Additionally, the review included one RCT conducted in multiple countries (Sweden, Germany, Belgium and the Czech Republic). Of all studies, 20 were web-based interventions, while four studies were conducted on a mobile phone. Large differences in sample size between the studies were observed, ranging from 76 to 3422 participants. Overall, 16 studies targeted adolescents with participant ages ranging between 15 and 24, and 8 studies targeted adults with mean ages between 37 and 47 years.

Adolescents

| Author (year) | Country | Sample (N, target group, inclusion criteria) | Intervention characteristics (Delivery mode, content, duration) | Study conditions (exp.(EG) / control (CG)) | Follow-up (% , N) | Outcome measures | Summary of findings |
|----------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bertholet, N., Cunningham, J. A., Faouzi, M., Gaume, J., Gmel, G., Burnand, B., & Daeppen, J.-B. (2015b) | Switzerland | (N=896) Young Swiss men with low-risk drinking* from the general population (mean age 21, EG, N=451, CG, N=445) | Web-based , two-arm, parallel-group, single-session, brief alcohol primary prevention intervention. Preventing an increase in consumption. PNF, feedback on consequences, caloric value alcohol, computed BAC, risks of alcohol consumption, information on health, recommendations | C-SURF (Cohort study on substance use risk factors) and internet trial vs assessment only controls | One- and six-months (94.2% and 93.2% follow-up rate) | WAC, HED. Secondary outcomes: Number of reported alcohol-related consequences, AUDIT score | Beneficial intervention effects on number of drinks p/w at 1 month. No significant differences at 6 months. Short term (30day) protective effects of a primary prevention internet-based brief intervention were found. |
| Jander, A., Crutzen, R., Mercken, L., Candel, M., & de Vries, H. (2016) | Netherlands | (n=2649, Exp. N= 1622) Binge-drinking dutch adolescents (15-19yrs) from all educational levels from 34 schools | Non-blinded, two-arm, cluster RCT reporting a single-session motivational intervention developed as a game with computer-tailored feedback. Realistic scenarios (N=3) and advice | Experimental receives Alcohol Alert. Control receives baseline questionnaire. Same follow-up questionnaire | Four-month (N=824, 31.11% follow-up) | Reducing HED. Secondary outcomes: Reducing excessive drinking and WAC | Intervention effective in reducing HED in adolescents aged 15 years (P=.03). Effective for 16 year olds when they participated in at least two intervention sessions (P=.04). Prolonged use of intervention resulted in stronger reduction in HED. Low-adherence despite game elements. Characteristics associated with adherence were: Protestant, female, younger, a nonbinge drinker, and a higher education background. |
| Cunningham, J. A., Hendershot, C. S., Murphy, M., & Neighbors, C. (2012) | Canada | (N=425) Risky-drinking college students | 2-arm, web-based, parallel-group, single-session RCT with the intervention providing voluntary access to a PNF intervention, normative feedback and an assessment of the severity of the participant's drinking concerns | Experimental condition received web-based personalized feedback. Controls were assessment only. | Six-week (68%, N=290) | Reduction in risky drinking | No significant difference in drinking between conditions was observed. Web-based personalized feedback interventions offered to students on a voluntary basis may not have a measurable effect on risky drinking |
| Arnaud, N., Baldus, C., Elgan, T. H., De Paepe, N., Tonnesen, H., Csemy, L., & Thomasius, R. (2016) | Germany Belgium Sweden Czech Republic | (N=1449) Adolescents aged 16-18 with at-risk alcohol and other drug use in a convenience sample | Non-blinded, two-arm, web-based RCT consisting of a single session, tailored Brief Motivational intervention + PNF, feedback on BAC, MtC, benefits and potential gains, high-risk situations and behavioural coping strategies. | Single session web-based brief motivational intervention vs assessment only control group. | Three-month (N=211, 14.5%) | Differences in past month drinking for drinking frequency, quantity and frequency of HED. | Significant reduction in past month drinking of intervention group compared to control, in both the non-imputed (P=.0.10, for 'completers') and the EM-imputed sample (P=0.22). Secondary analyses: significant effect on drinking frequency (P=0.37) and HED frequency (P=.044) in the 'completers' sample, and on drinking quantity (P=.021) in the EM-imputed sample. No support for the secondary outcome measures was found. |
| Voogt, C. V., Kleinjan, M., Poelen, E. A. P., Lemmers, L. A. C. J., & Engels, R. C. M. E. (2013a) | Netherlands | (N=609) Heavy drinking adolescents (15-20yrs) with low educational background and high RtC (59.9% male) | A two-arm, web-based, parallel-group full-yautomated cluster RCT of the single-session personalized motivational intervention (+I-CHANGE model). Modified usability. Clustering based on school classes. | WDYD intervention vs assessment only controls. Total of 73 classes, Exp. 37 classes (N=319), C. 36 classes (N=291) | One- and six-month | Reduction in heavy drinking, WAC, and HED | Analysis revealed no significant intervention effects for any of the outcome measures at 1- and 6- month follow-up. First study to target this population. |
| Bertholet, N., Cunningham, J. A., Faouzi, M., Gaume, J., Gmel, G., Burnand, B., & Daeppen, J.-B. (2015a) | Switzerland | (N=737) Young men from a general population sample (average 21yrs) with unhealthy alcohol use | 2-arm, web-based, parallel-group RCT. Single-session, brief PNF intervention, plus feedback on the consequences of alcohol, caloric value, computed BAC, risk, information on alcohol and health, low-risk drinking limits. | Intervention consisted of assessment and elaborate feedback Control group received assessment only | One- and six-month (92% and 91% , respectively) | WAC (quantity/frequency) Secondary: HED prevalence at 1- and 6-months | Participants in the intervention group reported greater reductions in number of drinks/week than controls. No significant difference on binge drinking prevalence. Favourable intervention effect on AUDIT scores, but not on the number of consequences of alcohol use. |
| Bendtsen, P., Bendtsen, M., Karlsson, N., White, I. R., & McCambridge, J. (2015) | Sweden | (N=1605) Hazardous and harmful drinking university students in their 2nd, 4th, or 6th terms. | 2-arm, web-based, RCT. National provision of a single session, brief alcohol intervention consisting of immediate or delayed access to PNF intervention. Feedback on WAC, HED, eBAC, safe drinking limits, level of risk | Intervention consisted of assessment and personalized normative feedback. Assessment only controls. | Two month (CG 67.8% vs EG 49%) | Reduction in total WAC. Secondary : proportion drinking above national guidelines, frequency of drinking/ HED, DDD | No statistically significant differences, with some indication of possible benefit of 10 % reduction in total WAC in intervention group. Differences in effect sizes were observed between universities, with participants from a major university (N=365) reducing their WAC bij 14%. Lower than planned recruitment and differential attrition in the intervention (49%) and control group (68%) complicated interpretation. |
| Bewick, B. M., West, R. M., Barkham, M., Mulhern, B., Marlow, R., Traviss, G., & Hill, A. J. (2013) | UK | (N=1478) students (17-50yrs) at one UK university (70% female; EG, N=723; CG, N=755) | Non-blinded, web-based two-arm RCT of a single session PNF intervention.Feedback on three sections; alcohol consumption, social norms, generic information providing standard advice on calculating units, health risks, sensible drinking guidelines. | Unitcheck vs self-assessment control. Assessment at 1, 16 and 34 weeks (T1,2,3). Access to website between T1 and T2 (15 weeks). | One week (65%); 16 weeks (46%) and 34 weeks (40%) | Reduction in WAC, DDD. Assessed at baseline, T1, T2, T3. | All participants that completed assessments reducing consumption over the final week. Intervention group had greater predicted reduction in alcohol consumption. Increased number of visits to the intervention website was associated with an additional reduction in drinking. Intervention effect was sustained at week T3 (week 34) |

Adolescents

| Author (year) | Country | Sample (N, target group, inclusion criteria) | Intervention characteristics (Delivery mode, content, duration) | Study conditions (exp.(EG) / control (CG)) | Follow-up (% N) | Outcome measures | Summary of findings |
|----------------------------------------------------------------------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Kypri, K., Vater, T., Bowe, S. J., Saunders, J. B., Cunningham, J. A., Horton, N. J., & McCambridge, J. (2014) | New Zealand | (n=3422) Hazardous or harmful drinking students (17-24yrs) from 7 new Zealand universities | A multisite (7 universities), double-blind, web-based, two-arm parallel-group RCT. Single session personalized normative feedback or screening alone | Feedback on alcohol expenditure, peak BAC, alcohol dependence, and access to help and information | Five-month (83%) | DDD, WAC, academic problems score, participants exceeding medical guidelines | Only drinks per drinking day reduced significantly. However, when accounting for attrition, this effect was no longer statistically significant. A small reduction in the amount of alcohol consumed per typical drinking occasion may have been achieved. |
| Voogt, C. V, Kuntsche, E., Kleinjan, M., Poelen, E. A. P., Lemmers, L. A. C. J., & Engels, R. C. M. E. (2013b) | Netherlands | (N=907) Heavy drinking college students (18-24yrs) from either HBO (higher professional education) or universities | Two-arm, parallel group RCT of the single session web-based, Personalized brief motivation intervention applying Ecological Momentary Assessment (EMA). Content based on motivational interviewing and parts of the I-Change model. | Single session WDYD intervention. EMA with 30 weekly measurements. WDYD vs assessment only controls | 25 follow-up time-points in a six-month period | WAC, frequency of HED, heavy drinking status. | Varying intervention effects at multiple follow-up endpoints. Intervention effects for A) weekly alcohol consumption at 1,2,3,4,7 weeks. B) frequency of binge drinking at 1,2,7,12 weeks. C) heavy drinking status at 1,2,7,16 weeks follow-up. The commonly used one- and six-month follow-up points are relatively arbitrary |
| Voogt, C., Kuntsche, E., Kleinjan, M., Poelen, E., & Engels, R. (2014) | Netherlands | (N=907) Heavy drinking college students (18-24yrs) | Single-session, web-based, two-arm, parallel-group RCT of personalized WDYD brief alcohol intervention to reduce alcohol consumption and maintain reduction | Follow-up study of the single session WDYD intervention vs assessment only controls | One month (87.9%), three months (85.7%) and 6 months (82.1%) | Reduction in WAC and HED frequency | Significantly lower WAC in experimental than in control condition, which was sustained at 3-month follow-up. Significantly higher WAC for controls than for experimental at 1-, 3-, and 6-month follow-up. Significantly lower HED frequency in experimental condition throughout the EMA and sustained at 6-month follow-up. |
| Savage, J. E., Neale, Z., Cho, S. Bin, Hancock, L., Kalmijn, J. A., Smith, T. L., ... Dick, D. M. (2015) | USA | (n=231) First-semester college freshman with heavy drinking (72.2% females, mean age 18) | Five-arm RCT testing two online PNF alcohol prevention programmes: standard programme, and a level of response to alcohol based programme (LRB). Once per week (50min) video + comprehension quiz for four weeks vs assessment only control group | High level of response to alcohol (High-LR) in LRB programme (High LR-LRB), Low-LR-LRB, Low LR-SOTA, high LR-SOTA. | Week 1, 4, 8 and 22. | Number of days drinking, DDD, drinks per HED, number of days with HED | All alcohol prevention programs had a greater reduction in maximum drinks per occasion and AUD symptoms than controls. Limited evidence for interactions between LR and prevention group (both LRB and SOTA) in predicting change in alcohol use behaviours. Low-LR showed greater decreases in drinking behaviour, especially risky behaviours than high LR individuals. |
| Collins, S. E., Kirouac, M., Lewis, M. A., Witkiewitz, K., & Carey, K. B. (2014) | USA | (N=724) Undergraduate students with ≥ 1 HED/past month (56% female) at a 4-year university. (mean age 20.78) | Three-arm, parallel group RCT consisting of Web-based decisional balance feedback (DBF), PNF, or assessment only control. Assessments included measures of motivation to change, drinking quantity norms, WAC, and alcohol-related problems. | Single session exposure to web-based DBF, PNF or control only. Web-based assessment at baseline. | One-, six-, and Twelve-month (91%, 84% and 74%) | Reductions in WAC (quantity and frequency) and alcohol-related problems | At 1-month follow-up, DBF and PNF participants reported reductions in alcohol-related problems. Only PNF reduced WAC. At 6-month follow-up, only DBF showed significant reductions in drinking quantity and alcohol-related problems. Neither DBF or PNF maintained reductions at 12-month follow-up. |
| Foster, D. W., Neighbors, C., & Pai, A. (2015) | USA | (N=162) Heavy drinking university undergraduates Mean age 24.37, SD = 6.81, 27% male | Three-arm, web-based single-session RCT comparing a non-weighted decisional balance proportion (DBP) to a participant weighted DBP (wDBP) or to control. Also explored DBP as motivation to change (MtC) precursor. | wDBP: alcohol DB + personalized weights DBP: Alcohol DB C: Physical activity DB | One month | Decrease in drinking and alcohol related negative consequences | DBP reduced weekly drinking compared to control group. Weighted DBP significantly reduced drinking frequency compared to controls. No significant difference between the weighted DBP and the non-weighted DBP. A significant reduction in HED was found for those with high DBP at baseline., i.e. for those who attached the highest importance of reducing alcohol use. |
| Gajecki, M., Berman, A. H., Sinadinovic, K., Rosendahl, I., & Andersson, C. (2014) | Sweden | (n=1932) Swedish university students with problematic alcohol use. | Three-arm RCT testing two motivational smartphone applications, promilekoll (Swedish government monopoly app) and partyplanner (designed by researchers), versus assessment only control group. | Promilekoll: real-time eBAC calculation. Partyplanner: real-time eBAC with planning and follow-up function. | Seven weeks (60.7% - 77.3%, higher among heavier drinkers and group 2) | electronic Blood Alcohol Concentrations (eBAC) to reduce binge drinking | Group 1 participants increased the frequency of their drinking occasions compared to controls (P=.001), which only accounted for men. The apps studied using eBAC calculation did not seem to affect alcohol consumption among university students. The promillekoll app may have had a negative effect on frequency of drinking among men. |
| Suffoletto, B., Kristan, J., Chung, T., Jeong, K., Fabio, A., Monti, P., & Clark, D. B. (2015) | USA | (n=765) Young adults (18-25yrs) drinking above the low-risk limit not seeking alcohol treatment, enrolled from 4 emergency departments. | Three-arm RCT testing interactive text-messaging. SMS Assessments + Feedback (SA+F), SA only, or control with 2:1:1 allocation. 12 week duration. SA+F: Thursday message querying drinking plans and drinking limit goal commitment. Both SA+F and SA: Sunday message querying drinking quantity, SA+F also received feedback. | SA+F received Thursday and Sunday message and feedback, SA received Sunday message. Assessment only control | 3-, 6-, and 9-month follow-up (78%, 63% and 55% respectively) | Reduction in binge drinking. Self-reported alcohol consumption and alcohol-related injury | At 9-months, participants in the SA+F group reported greater reductions in the number of binge drinking days than participants in the control group. Lower binge drinking prevalence, less DDD, and lower alcohol-related injury prevalence. No effect for SA-group compared to controls. Interactive text messaging was more effective than self-monitoring or 16 controls in reducing alcohol consumption and related injury prevalence up to six months after intervention completion. |

Adults

| Author (year) | Country | Sample (N, target group, inclusion criteria) | Intervention characteristics (Delivery mode, content, duration) | Study conditions (exp.(EG) / control (CG)) | Follow-up (% , N) | Outcome measures | Summary of findings |
|------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| van Lettow, B., de Vries, H., Burdorf, A., Boon, B., & van Empelen, P. (2015) | Netherlands | (N=2634) Excessive drinking adults (51.3% males, mean age 37.03 (SD 15.19) | 2-arm Web-based RCT strategies (ie, prototype alteration and cue reminders) within an existing single-session PNF intervention. 1) Original Drinktest, 2) Drinktest + prototype alteration , 3) Drinktest + cue reminder (bracelet), and 4) (2+3). | Either drinktest only or one of extended intervention arms with prototype alteration and/or cue reminder strategy. | One- and six-month (52.2%) Lower in (1) (42.6%) | Differences in drinking behaviour, intentions, and behavioural willingness | All conditions showed reductions in drinking behaviour and willingness to drink, and increased intentions to reduce drinking. Prototype alteration and cue reminder strategy were both more effective in reducing alcohol consumption than drinktest only condition. Condition 4) did not produce a synergistic effect. |
| Schulz, D. N., Candel, M. J., Kremers, S. P., Reinwand, D. A., Jander, A., & de Vries, H. (2013) | Germany | (n=448) high-risk adult drinkers (mean age 42 years) | Single-blind three-arm RCT. Personalized, single session, brief motivational intervention with two experimental subgroups; alternating feedback provision (series of messages) versus summative feedback (all feedback at once). | All groups conducted the intervention. Experimental conditions received tailored feedback per part or all at once | Three month (44%) Six month follow-up (EG: 21.1% vs CG 5.8% (P=.02) | Reducing alcohol intake. Drinking behaviour, health status. | No statistically significant effect between the experimental conditions, or between experimental and controls. Dropout during the first visit to the website was significantly lower in the alternating than in the summative condition. |
| Wiers, R. W., Houben, K., Fadardi, J. S., van Beek, P., Rhemtulla, M., & Cox, W. M. (2014) | Netherlands | (N=314) Self-selected problem drinkers (Mean age 47) | Five-arm RCT. Participants were assigned to one of four experimental conditions reflecting variations of cognitive bias modification (attention control or one of three varieties of approach-bias re-training) or sham training control condition. | Pretest, four sessions of training and a posttest, with time between tests ranging from 2 to 14 days. | 1-month (35%) and three-month (28%) after posttest(44%) | WAC, HED. | General pattern that participants in all conditions, including the control-training condition, reduced their drinking. The main hypothesis of stronger alcohol reduction in experimental conditions (after active training) than in the sham-control condition was falsified. |
| Sinadinovic, K., Wennberg, P., Johansson, M., & Berman, A. H. (2014) | Sweden | (n=633) Internet help seekers with at least hazardous alcohol use (mean age 44 (SD 13.6) | Three-arm RCT. One brief PNF intervention (eScreen) and one extensive MI-based cognitive behavioural self-help programme(Alkoholhjälpen.se) with an assessment-only control condition | eScreen, Alkoholhjälpen.se, or assessment only | 3-, 6-, and 12-month follow-up | Reducing Problematic alcohol use, WAC (quantity and frequency) | All groups reduced alcohol use at 3 month follow-up (P<.001) and maintained this reduction at 6- and 12-month.Cognitive-behavioural extended self-help in combination with other external interventions during the trial was more effective in changing alcohol use than brief intervention or assessment only. |
| Gustafson, D. H., McTavish, F. M., Chih, M.-Y., Atwood, A. K., Johnson, R. A., Boyle, M. G., ... Shah, D. (2014) | USA | (n=349) Patients leaving residential treatment for AUDs (mean age 38 (SD 10), 60% male, 79% unemployed) | Unblinded two-arm, parallel-group RCT testing a smartphone application. Based on self-determination theory. Either treatment as usual (TAU) or TAU + smartphone app to support recovery (A-CHESS) for 8 month period. | The intervention group received TAU + A-CHESS for 8-months and TAU during 4 month follow-up. | 4 month follow-up. Surveys taken 4, 8 & 12 months after discharge. | Reduction in HED frequency, greater abstinence, fewer negative consequences. | Patients in the A-CHESS experimental condition reported significantly fewer risky drinking days than patients in the control group |
| Hester, R. K., Lenberg, K. L., Campbell, W., & Delaney, H. D. (2013) | USA | (n=189) Heavy drinkers that want to achieve and maintain abstinence that are new to the organization 'SMART Recovery'(60% female, mean age 44.3 (SD 10.9) | Two-arm RCT of (1)Smart Recovery (SR) and (2) Web-based, abstinence-oriented, cognitive behavioural web application 'Overcoming Addictions' extension + SR (OA+SR). Mutual help framework with in-person meetings, online meetings, a forum and other resources. | SR or SR+OA. Based on 4-points: 1)building and maintaining motivation 2) dealing with urges, 3) managing thoughts, feelings, and behaviours, 4) cultivating a lifestyle balance | Three month programme. Three-month follow-up | Percent days abstinent, DDD, and alcohol-related consequences | All groups reduced their drinking (percent days abstinent AND mean DDD) and alcohol/drug related consequences at follow-up compared to baseline assessment. OA+SR = SR. Number of face-to-face meetings significantly related to all three outcome measures. Both interventions equally effective in helping recovery from problem drinking. Follow-up higher among individuals with higher education |
| Campbell, W., Hester, R. K., Lenberg, K. L., & Delaney, H. D. (2016) | USA | (n=189) Heavy drinkers that want to achieve and maintain abstinence (60% female, age 44.3 (SD 10.9) | 3-month follow-up of Hester <i>et al</i> (2013) | Control receives SMART Recovery program (SR). Experimental receives SR + OA programme for 3 months. | 6-month outcomes. 3-month follow-up | Percent days abstinent, DDD, and alcohol-related consequences | Highly significant improvement for all groups. No significant difference between groups at three and six months. Abstinent participants at commencement performed significantly better than those still drinking. Particularly effective for individuals in the action stage of change. |
| Stoner, S. A., Arenella, P. B., & Hendershot, C. S. (2015) | USA | (N=76) Treatment seeking participants with an alcohol use disorder (mean age 37) | Two-arm, parallel-group RCT of a mobile phone intervention for improving adherence to Naltrexone. All participants received Naltrexone with a medication event monitoring system and a prepaid smartphone and received a daily text message querying medication side-effects, alcohol use and craving. Duration 8 weeks | Intervention arm received additional medication reminders and adherence assessment | Duration 8 weeks. Survival analyses at 8 weeks | Proportion of participants with adequate adherence (≥ 80% of doses taken through week 8) | No significant difference between intervention and the control. Mean adherence at study midpoint (4weeks) was 83% in the intervention condition and 77% in the control condition. Intervention condition maintained adequate adherence significantly longer (19 days vs 3 days, P=.04). Medication adherence did not predict drinking outcomes. Additional text messages did not further improve medication adherence. |

Interventions targeting adolescents

Of the 16 studies aimed at adolescents, 10 specifically involved students, two targeted adolescents independent of education level, while one study targeted adolescents with a low educational background. Two studies targeted males only (Bertholet *et al.*, 2015a; 2015b), while all other included both males and females. All studies aimed to achieve a reduction in alcohol consumption, 14 of which targeted adolescents with problematic alcohol consumption, one included participants independent of alcohol consumption levels (Bewick *et al.*, 2013) and one aimed for the maintenance of low-risk drinking profiles, e.g. preventing alcohol consumption to exceed the recommended guidelines (Bertholet *et al.*, 2015b). Outcome measures differed somewhat between studies. Nine studies aimed for a reduction in both weekly alcohol consumption (WAC) and heavy episodic drinking (HED) (Bertholet *et al.*, 2015a; Bertholet *et al.*, 2015b; Voogt *et al.*, 2013a; Voogt *et al.*, 2013b; Voogt *et al.*, 2014), extended with additional measures of alcohol-related problems (Collins *et al.*, 2014; Foster *et al.*, 2015), injury (Suffoletto *et al.*, 2015) or academic problems (Kypri *et al.*, 2014) into account. Three studies aimed for a reduction in heavy episodic drinking (Cunningham *et al.*, 2012; Gajecki *et al.*, 2014; Jander *et al.*, 2016). Four studies measured a reduction in total alcohol consumption, either on a weekly basis (Bewick *et al.*, 2013; Bendtsen *et al.*, 2015) or a monthly basis (Savage *et al.*, 2015; Arnaud *et al.*, 2016).

Of the 16 interventions targeting adolescents, 14 were single session brief interventions. All trials testing the effectiveness of brief interventions compared a single experimental condition with an assessment only control condition. Different theoretical approaches were used for the trials, primarily building on personalized normative feedback and/or motivational interviewing techniques. Seven studies of six separate RCT designs provided both personalized normative feedback and aspects of motivational interviewing. These were both studies of Bertholet *et al.* (2015a; 2015b), the studies by Voogt targeting individuals with a high- (2013b; 2014) and a low-educational background (2013a), as well as the studies by Bewick *et al.* (2013) and Arnaud *et al.* (2016). Furthermore, three studies provided personalized normative feedback without aspects of motivational interviewing (Cunningham *et al.*, 2012; Kypri *et al.*, 2014; Bendtsen *et al.*, 2015). The study by Jander *et al.* (2016) was a brief motivational intervention designed as a game, which showed realistic scenarios after drinking too much alcohol and provided advice on how to drink less. The study by Collins *et al.* (2014) tested the effectiveness of the decisional balance procedure to personalized normative feedback and an assessment only control group. Foster and colleagues (2015) tested the effectiveness of a conventional, non-weighted, decision balance group to a decisional balance group that had to assign weights of relative importance to the different items, to an assessment-only control group. The effect of assigning weights was tested since not all items may be equally important precursors for an individual's readiness to change. Additionally, the study by Gajecki *et al.* (2014) tested two smartphone applications ('apps') that provided information on real-time estimated blood alcohol concentration (i.e. one aspect of personalized feedback) with the aim to increase participants motivation to reduce weekend binge drinking.

Besides these brief interventions, two of the trials targeting adolescents were non-brief interventions (Savage *et al.*, 2015; Suffoletto *et al.*, 2015). The trial by Savage *et al.* (2015) was based on both personalized feedback and motivation interviewing techniques. Here, participants in the experimental group watched a weekly 50-minute video followed by a comprehension quiz for four consecutive weeks. The three-arm RCT by Suffoletto *et al.* (2015) was based on the theory of planned behavior and aimed to reduce weekend drinking quantity and binge drinking. The intervention had a twelve week duration. Here, one experimental arm received a weekly text message on Thursday querying weekend drinking plans and drinking limit goal commitment, as well as a Sunday text message querying drinking quantity. Thereafter, participants received personalized feedback. The

other experimental arm only received the weekly text message on Sunday, and controls only conducted the assessments at baseline, 3-, 6-, and 9-month follow-up. The following section is used to explicate the effectiveness of these interventions.

Effectiveness of interventions targeting adolescents

Of the 16 interventions targeting adolescents, 11 interventions were found effective while five studies were not able to show intervention effectiveness. A distinction is made on the basis of intervention type. First, interventions that contain aspects of both motivational interviewing and personalized normative feedback are described, after which interventions providing either PNF or motivational are discussed. Thereafter, interventions adopting a decisional balance approach and non-brief interventions are discussed.

Motivational interviewing + personalized normative feedback

The studies described here used both motivational interviewing components as well as personalized normative feedback to participants.

The study by Bertholet (2015a) targeting young Swiss males with unhealthy alcohol use from all educational backgrounds aimed for a reduction in weekly alcohol consumption (quantity and frequency). Intervention group participants significantly reduced the number of drinks per week as well as the AUDIT scores compared to controls. This reduction was maintained at 1- and 6-months follow-up.

The other study by Bertholet *et al.* (2015b) targeted young Swiss males from the general population with low-risk drinking, i.e. drinking within the national recommended guidelines. The study found a beneficial intervention effect for the number of drinks per week at one-month follow-up, but this effect was not sustained at six-months.

The study by Voogt (2013b) targeted heavy drinking college students to reduce their weekly alcohol consumption, the frequency of binge drinking and heavy drinking status. The authors applied an Ecological Momentary Assessment approach, in which 25 follow-up points were used following the single-session intervention. This approach was chosen because alcohol consumption can fluctuate over time, which might consequently impact the measurement of intervention effects. The authors found intervention effectiveness for weekly alcohol consumption at 1, 2, 3, 4 and 7 weeks follow-up. For frequency of binge drinking, intervention effects were found at 1, 2, 7 and 12 weeks and for heavy drinking at 1, 2, 7 and 16 weeks follow-up. The consecutive study (Voogt *et al.*, 2014) assessed alcohol use at 1-, 3-, and 6-month follow-up. The study showed that the effect of the intervention was sustained at 1- and 3-month follow-up. Additionally, the authors found that the difference in intervention effectiveness could be attributed to significantly higher alcohol consumption in the control condition compared to the experimental condition at 1-, 3-, and 6-month follow-up. Furthermore, the study showed significantly lower frequency of binge drinking in the experimental condition than in the control condition, which was sustained at 6-month follow-up.

Another study by Voogt (2013a) used the same intervention but targeted heavy drinking adolescents (15-20) with a low educational background instead of a high educational background. Although the authors did adapt the language use to the target audience, this study found no significant intervention effect for any of the selected outcome measures (heavy drinking status, WAC, frequency of HED).

The study by Bewick (2013) aimed for a reduction in both weekly alcohol consumption and heavy episodic drinking among university students. Intervention group participants had access to the intervention website between baseline assessment for a period of sixteen weeks. The authors found

the greatest reduction in weekly alcohol consumption for participants in both groups given that they completed at least two out of five assessments, as well as for WAC in intervention group participants compared to controls. Additionally, the study found an increased reduction in alcohol consumption for participants that visited the intervention website more often, suggesting that repeated access to the intervention might help maintain behaviour change. These effects were sustained at 34 weeks, which is 19 weeks after the intervention website was taken offline.

In the multi-country study by Arnaud et al (2016) – targeting adolescents with at-risk alcohol use (i.e. drinking above the national guidelines) – a significant reduction of drinking in the past-month was found in the intervention condition compared to controls at the single three-month follow-up point. This effect was found in both the non-imputed ('completers') and the imputed sample

Personalized normative feedback

Three studies provided personalized normative feedback to participants, which are discussed separately below.

The study by Cunningham (2012) aimed at a reduction in risky drinking among college students showing risky drinking behaviour (AUDIT-C score of ≥ 4). The study found no significant differences between conditions at the single six-week follow-up assessment.

The study by Bendtsen *et al.* (2015), targeting university students with hazardous drinking (\geq one HED episode in past three months) found no statistically significant effect, although there was some indication of a possible reduction of 10% in total WAC in the intervention group. Study interpretation was complicated by a low recruitment (3%) and a differential attrition rate at the two-month follow-up interval (51% dropout in experimental group vs 32% in the control group).

The study by Kypri (2014) targeting hazardous drinking university students from seven New Zealand universities initially found intervention effectiveness on one out of six primary outcome measures, which was the number of drinks per drinking day. However, when accounting for attrition, this finding was no longer significant.

Motivational interviewing

Jander *et al.* (2016) conducted a single session motivational intervention developed as a game among binge drinking adolescents from all educational levels. At the four-month follow-up interval, the game was found to be effective in reducing HED for 15 year olds, and effective for 16 year olds when they had participated in two or more intervention sessions (Jander, 2016). Prolonged use of the intervention showed a stronger HED reduction. No significant differences were found regarding the game's effectiveness in reducing HED among 18 and 19 year old adolescents.

Gajecki *et al.*, (2014) conducted a three-arm RCT testing the effectiveness of one smartphone app developed by the Swedish government and one web-based app for party occasions, with an assessment only control group. The smartphone monopoly app, promillekol, offered real-time estimated blood alcohol concentration (BAC). The web-based app, partyplanner, offered real-time estimated BAC with planning and follow-up function. Participants in the first experimental condition (promillekol) increased their drinking frequency compared to control, which accounted only for males upon further analysis. Both apps using eBAC calculation did not seem to affect participants' heavy episodic drinking at seven weeks follow-up, although the smartphone app might have actually increased the frequency of drinking.

Decisional balance approach

Collins et al (2014) conducted a three-arm RCT that compared a single session web-based Decisional Balance Feedback (DBF) and a single session web-based personalized normative feedback (PNF) intervention to an assessment only control group with 1-, 6-, and 12-months follow-up. At 1-month follow-up, both DBF and PNF participants reported reductions in alcohol-related problems, while only PNF participants actually reduced their drinking quantity and frequency. Somewhat contradictory to the findings at 1-month follow-up, at 6-months, only the DBF participants showed significant reductions in drinking quantity and alcohol-related problems. Neither group maintained any of the reductions at 12-month follow-up compared to controls. This provides some preliminary evidence of effectiveness of web-based DBF and PNF interventions for college drinkers, with DBF showing somewhat longer lasting effects.

Foster(2015) conducted a three-arm RCT of a single session decisional balance intervention among heavy drinking university undergraduate, comparing a non-weighted decisional balance proportion (DBP) and a participants weighted DBP (wDBP) to an assessment only control condition. Weights based on the relative importance of items, thereby being a measure of motivation to change. At 1-month follow-up, the non-weighted intervention was effective in reducing weekly alcohol consumption compared to controls, while the weighted intervention was effective in reducing drinking frequency. The study showed that decisional balance intervention can be effective in reducing drinking, but there was no evidence for the addition of weights.

Non-brief interventions targeting adolescents

Savage *et al.* (2015) conducted a five-arm randomized controlled trial in which two distinct online alcohol prevention programs were tested among heavy drinking college freshman. One program was a standard 'state-of-the-art' (SOTA) programme, while the other program was adapted to take into account participants' level of response to alcohol (LRB, level of response-based). This stems from the notion that people with a lower level of response to alcohol are at higher risk of becoming heavy drinkers. Participants were stratified based on their LR (either high or low) and consequently divided into the LRB- or the SOTA-programme. These groups were compared to a control group with assessments only. Both programmes consisted of a 50 minute video followed by a comprehension quiz for four consecutive weeks. The study found that all groups (high-LR-LRB, Low-LR-LRB, Low LR-SOTA, high LR-SOTA) reduced their maximum drinks per occasion and AUD symptoms. No difference was found between the programmes. However, in both groups, low-LR participants showed greater reductions in drinking behaviour than high-LR participants. This indicates that programs aimed at preventing the development of heavy drinking status might be most effective for those at highest risk of heavy drinking.

Suffoletto *et al.* (2015) conducted a three-arm RCT with weekly SMS assessment during 12 weeks, aimed at a reduction in HED. One group received a text message each Thursday querying weekend drinking plans and prompting drinking limit goal commitment, as well as an assessment on Sunday querying weekend drinking quantity (SA+F group, SMS assessment + feedback group). The SA+F group also received tailored feedback. The SMS assessment only group received the Sunday assessment, but not the Thursday assessment querying weekend drinking plans. The control group only conducted the assessment at trial commencement, after three months and at 3- and 6-month follow-up. The SA+F group reported less frequent HED, less DDD, and lower alcohol-related injury prevalence than control group. The SMS assessment only (=self-monitoring) did not report greater reduction compared to control. Interactive text messaging with tailored feedback was more effective than SA only or control up to six-months, but this finding was not prolonged at 9-months.

Interventions targeting adults

Eight studies were included that targeted adults, with 7 unique trial designs since two consecutive studies were included (Hester *et al.*, 2013; Campbell *et al.*, 2016). All participants were problematic alcohol users, with studies aiming to reduce problematic alcohol consumption (van Lettow, 2015; Wiers, 2014; Schulz, 2013; Sinadinovic, 2014; Gustafson, 2014), achieve and maintain abstinence (Hester, 2013; Campbell, 2016), or increase medication adherence (Stoner, 2015). Six studies were web-based, while two were conducted on smartphones (Gustafson *et al.*, 2014; Stoner *et al.*, 2015).

Of the eight randomized controlled trials, two have been distinguished as brief psychological interventions (van Lettow, 2015; Schulz, 2013). One study applied principles of cognitive behavioural therapy (Sinadinovic, 2014) and one study applied principles of cognitive bias modification (Wiers *et al.*, 2014). Three RCTs aimed to prevent relapse among alcohol dependent individuals (Gustafson, 2014; Hester, 2013; Campbell, 2016). Lastly, one intervention targets medication, more specifically medication adherence, in the treatment of AUD (Stoner, 2015).

Effectiveness of interventions targeting adults

Here, the effectiveness of the interventions targeting adults is addressed. Again, a distinction is made based on intervention type. First, brief psychological interventions are touched upon, after which interventions applying cognitive behavioural therapy and cognitive bias modification are discussed. Additionally, one intervention was based on self-determination theory, and one intervention provided medication reminders via text-message to increase medication adherence.

Brief psychological interventions

Van Lettow *et al.* (2015) tested the effectiveness of adding two online strategies, prototype alteration and cue reminders (separately and combined) to complement an online brief motivational and social norms intervention (van Lettow, 2015). The study showed that both an online brief alcohol intervention complemented with prototype alteration as well as a BI with cue reminder strategy were more effective in reducing alcohol consumption than the brief intervention only at one- and six-month follow-up. The condition providing both prototype alteration and cue reminders was not more effective than BI with one additional strategy (van Lettow, 2015).

Schulz *et al.* (2013) conducted a three-arm RCT which tested the effectiveness of a single session web-based tailored intervention with two varieties of feedback provision, with an assessment only control condition. The intervention was comprised of three separate parts, and experimental group participants either received feedback at the end of each session (alternating feedback condition) or all feedback at once upon completion (summative feedback condition). The experimental conditions showed a larger, but not significant, reduction in the number of drinks per week compared to controls. No significant difference in intervention effectiveness was found between the different ways of feedback provision (Alternating vs summative), although dropout was lower in the alternating condition.

Cognitive behavioural therapy

Sinadinovic *et al.* (2014) conducted a three-arm RCT which compared two online interventions, a personalized normative feedback brief intervention and an extensive self-help program (consisting of 18 modules, which includes cognitive behavioural therapy and MI aimed at self-help), with a control group. The study showed that all groups reduced their alcohol consumption at 3-month follow-up, which was maintained at 6- and 12-months. Cognitive behavioural extended self-help was more effective in reducing alcohol use than both the personalized normative feedback intervention and the control condition. The effect was strongest among participants that reported to have accessed external alcohol interventions during the trial.

The two consecutive studies by Hester *et al.* (2013) and Campbell *et al.* (2016) targeted heavy drinkers that wanted to achieve and maintain abstinence from alcohol. The program consisted of a three-month, abstinence-oriented, cognitive behavioural web application, which they received in addition to the face-to-face SMART recovery programme. Control group participants received the SMART recovery programme. Hester (2013) showed that both participants in the control condition receiving the SMART recovery treatment as usual and participants in the SMART recovery + web-based extension 'Overcoming Addictions' significantly reduced their drinking at 3-month follow-up compared to baseline, both regarding percent days abstinent as well as the number of risky drinking days. Both interventions equally effective in helping recovery from problem drinking. The results from the three-month follow-up study (Campbell, 2016) show a highly significant improvement from baseline to follow-up for all groups, with no significant difference between any of the groups at three and six months. Participants that stopped drinking before trial commencement performed significantly better than those still drinking upon commencement.

Cognitive bias modification

The study by Wiers (2014) tested the effectiveness of four varieties of cognitive bias modification among self-selected problem drinkers. The experimental conditions either received attention control training or one of three varieties of approach-bias re-training, against a sham-training control group. The study showed that participants in all conditions, including the control condition, reduced their drinking at one- and three-month follow-up. At both follow-up moments, approach-bias re-training had a stronger effect than attention control training. However, caution in interpreting the data is warranted considering that no significant differences between approach-bias re-training and control condition were found, and a reduction in drinking was observed across all conditions.

Self-determination theory

The study by Gustafson *et al.* (2014) is based on self-determination theory and targeted patients leaving residential treatment for alcohol use disorders. The intervention consisted of eight month access to a smartphone application in addition to treatment as usual, with four month follow-up consisting of treatment as usual. Controls received treatment as usual without the smartphone app for a period of twelve months. The researchers showed effectiveness of the mobile application A-CHESS, with participants in the experimental condition reporting significantly fewer risky drinking days after leaving residential treatment than those in the control group.

Medication adherence reminder

The study by Stoner *et al.* (2015) aimed to increase adherence to Naltrexone (a medication for AUDs) among treatment seeking participants with an alcohol use disorder. All participants received Naltrexone with a medication event monitoring system and a prepaid smartphone, and received daily text-messages querying medication side effects, alcohol use, and craving for a period of eight weeks. Intervention group participants received additional medication reminders and an adherence assessment. The researchers found no significant difference in adequate adherence (>80%) between the experimental and the control condition. Survival analysis at 8 weeks found that the intervention condition maintained adherence significantly longer during the first month of treatment (19 days vs 3 days). However, neither medication adherence nor additional text messages predicted drinking outcomes.

5. Discussion

The aim of this study was to determine the evidence of ehealth interventions to complement or replace care at general practices in light of problematic alcohol consumption. This study reviewed RCT in the English language published between 2012 and 2017 in PubMed. A total of 24 articles were included describing the effectiveness of 22 ehealth interventions targeting alcohol consumption. These studies evaluated a variety of internet-based (N=20) and mobile phone (N=4) interventions predominantly targeting adolescents (N=16) with problematic alcohol use (N=14).

Six out of seven interventions targeting adolescents that included both motivational feedback components and personalized normative feedback were found effective in reducing alcohol consumption. The study that did not find effectiveness targeted adolescents with a low educational background. This is interesting because the same intervention was effective in reducing alcohol use among adolescents following higher education. Adapting language use to match the target audience was not sufficient to overcome the observed difference in effectiveness. All six studies found effective maintained the reduction at one, three- or six-month follow-up, except for the study aiming to prevent an increase in alcohol consumption rather than reducing problematic consumption. Thus, it becomes clear from the present study that particularly brief interventions aiming to reduce problematic alcohol consumption, applying both motivational interviewing and personalized normative feedback, are most effective in reducing consumption and sustaining this reduction.

Interestingly, none of the three brief interventions applying only personalized normative feedback, without motivational interviewing aspects, were found effective. Additionally, the smartphone apps providing estimated blood alcohol concentrations to reduce binge drinking were not found effective, where participants using one such app actually significantly increased their drinking frequency. It can therefore be argued that brief interventions applying only PNF are less effective than more extended (brief) interventions applying both PNF and motivational interviewing. In line with this observation, both more extended programmes which offered either a weekly (50minute) video for four consecutive weeks or a biweekly text-message assessment for twelve consecutive weeks were found effective in reducing alcohol consumption. Similarly, the study comparing a decisional balance intervention with personalized normative feedback found sustained effects for the decisional balance group at twelve-month follow-up, but not for the PNF. This corresponds to findings from a literature review by Riper *et al.* (2011), which found a significant difference in effectiveness between single session personalized normative feedback and more extended ehealth interventions. Another interesting finding to consider in future research is the higher intervention effectiveness among participants with a low level of response to alcohol, indicating that interventions may be most effective for those at highest risk of heavy drinking.

Similar to the studies among adolescents, studies targeting adults also found greater effectiveness for more extended interventions compared to brief interventions. Brief motivational interventions were more effective when complemented with prototype alteration or cue reminder strategies, which was maintained at one- and six-months follow-up. Also, the study comparing normative feedback with an extensive cognitive behavioural self-help programme found greatest effectiveness for the extended intervention.

Regarding the interventions targeting adults, only two out of eight were able to show significant differences between experimental and control conditions. Important to note here is that in four out of eight interventions, all groups, including the control condition reduced their alcohol consumption. This may be explained by three factors. Firstly, five out of eight studies targeting adults complemented treatment as usual with an ehealth intervention. Although different intervention

types were provided, all participants received some sort of intervention. The other factor that might explain the reduction in all groups is the fact that in these trials, participants were self-selected problem drinkers actively looking for help via the internet. Consequently, these participants likely had a higher motivation to change. This corresponds to the Transtheoretical Model (Prochaska & DiClemente, 1983; Prochaska, DiClemente & Norcross, 1992), which makes a distinction between different stages of change to capture the process of intentional behaviour change, see figure 2. Those in the action stage of change see more pros than cons to changing behaviour, while those in earlier stages see relatively more cons than pros to change behaviour, thereby impeding behaviour change. It became clear from the present study that interventions were particularly effective among participants with a higher decisional balance proportion at baseline, representing the ratio between pros and cons (Foster *et al.*, 2015). Similarly, Hester *et al.* (2013) and Campbell *et al.* (2016) found the highest effectiveness for those in the action stage of change.

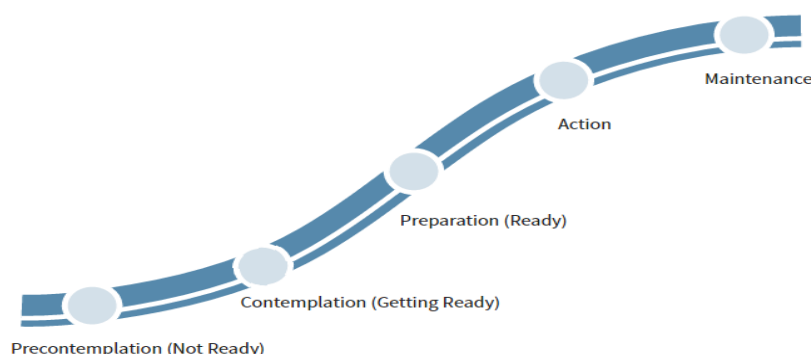


Figure 2: The transtheoretical Model

A third factor that may explain the observed reductions in alcohol consumption among control groups relates to self-monitoring. Self-monitoring has been defined as “any behaviour that entails reflecting on and providing self-reports about a specific behaviour (here: drinking) ..., regardless of the mode of reporting” (Simpson *et al.*, 2005, P.241). Participants that conducted one or multiple assessments without being subjected to the intervention may still be prone to the effects of self-monitoring. Multiple studies (Bewick *et al.*, 2013; Hester *et al.*, 2013; Schulz *et al.*, 2013; Voogt *et al.*, 2013b; Wiers *et al.*, 2014; Sinadinovic *et al.*, 2014; van Lettow *et al.*, 2015; Campbell *et al.*, 2016) reported reductions in all groups at follow-up, meaning that control groups also reduced their alcohol consumption. The effect of self-monitoring seems larger for control groups conducting multiple follow-up assessments (Bewick *et al.*, 2013; Voogt *et al.*, 2013b). It is important that researchers keep the effect of self-monitoring into account in both the design of novel trials as well as in the evaluation of intervention effectiveness.

Inconsistencies between the studies

The studies when compared to one another exhibited various inconsistencies. The reason for these inconsistencies are not exactly clear. They may be explained by a variety of factors, including the arbitrariness of measurements due to fluctuating nature of alcohol consumption, different contexts relating to cultural or local contextual factors, attrition, participant readiness to change, aspects of intervention design such as language use, layout or mode of delivery (email/web/text-messages/smartphone). Previous research suggests that the prevalence of excessive drinking in some countries as well as cultural acceptance of this behaviour may provide a more challenging environment in some countries or regions than others (Moreira, Oskrochi, & Foxcroft, 2012). Also, another factor may be that some interventions are perceived as irrelevant due to normative feedback not actually representing their norms. Previous research showed that more distant

reference populations are less effective for preventing student alcohol misuse and related problems compared to proximal referents (Baer, Stacy & Larimer, 1991), which also accounts for same-sex norms compared to gender-nonspecific norms (Lewis & Neighbors, 2004).

Furthermore, there are notable differences between the different brief interventions included, with most but not all offering normative feedback, many but not all providing feedback on: financial consequences, caloric value of alcohol, estimated blood alcohol concentrations, risks, health information and advice, and more. It seems that more extensive feedback provision is associated with increased intervention effectiveness, although it is not known which of the intervention / feedback components reinforce or undermine effectiveness and whether or how these components interact.

The potentially biasing effect of fluctuating alcohol consumption

Voogt *et al.* (2013a; 2013b; 2014) point out that alcohol consumption has a fluctuating nature, particularly among college students. The (arbitrary) selection of follow-up time points to test intervention effectiveness may result in biased results due to these week-to-week variations in individuals' alcohol consumption. Imagine that the baseline assessment is completed during a high-risk drinking period (e.g. birthday celebration, holiday, end of semester), while the follow-up assessment is conducted during a low-risk period (e.g. exam weeks). This would result in biased conclusions on the effectiveness of the intervention. Therefore, the authors propose an ecological momentary assessment approach. Future research should preferably use short reference periods (i.e. weeks) with multiple follow-up time points (i.e. 25) to test whether findings are robust or vary over time. The potentially biasing effect becomes clear when looking at the results of the study of Voogt *et al.* (2013b): the authors found a significant effect for weekly alcohol consumption at 1-, 2-, 3-, 4- and 7-weeks follow-up; for frequency of HED at 1-, 2-, 7-, 12-weeks follow-up and heavy drinking status at 1-, 2-, 7-, and 16-weeks follow-up. If the authors would have chosen the commonly used one- and three-month follow-up time points, their conclusions would have been completely different than when they would have chosen, say, a single seven-week follow-up point. It thus seems that the commonly used follow-up points are indeed quite arbitrary. The present study therefore adopts the recommendation of the authors that future studies evaluating the effectiveness of alcohol (and other) interventions should where possible apply ecological momentary assessment. If undesirable or unfeasible, studies are recommended to take multiple follow-up endpoints and take the arbitrariness into account in designing the research to avoid potential biases.

Attrition rates

Large differences were observed in attrition rates (e.g. 'loss to follow-up', 'drop-out') between studies. The majority of studies reported follow-up rates between 80 and 50 percent, although some studies found attrition rates ranging from less than ten percent at six-month follow-up (Bertholet, 2015a; 2015b), to 85.5% at 3-months in a multi-country study (Arnaud, 2016) and 94.2% at 9-months after baseline assessment in the control condition (Schulz, 2013). The latter attrition rate was significantly higher in the control than in the experimental condition (94.2% vs 78.9%). Similarly, Bendtsen (2015) reported differential attrition rates between the experimental (68%) and control group (49%). In the later study the differential attrition may be explained by the fact that control group participants were aware their access to the intervention was delayed until after the 2-month follow-up assessment. Differential attrition was also observed in a 4-arm RCT comparing the online intervention 'drinktest' (control) with the same intervention complemented with either a prototype alteration strategy, a cue reminder strategy or both (van Lettow, 2015). Here, attrition was highest in the control condition receiving only the online brief intervention.

Several characteristics were associated with attrition. Studies under review reported higher attrition among heavier drinkers (Gajecki, 2014, Stoner, 2015). Lower attrition levels were associated with participants of a higher educational background (Hester, 2013; Voogt, 2013a; Voogt, 2013b; Jander, 2016), being younger, female, a non-binge drinker, Protestant (Jander, 2016), and participants in the action stage of change (Hester, 2013; Campbell, 2016; Jander, 2016). Additionally, attrition rates during the first visit to an intervention's websites may be lower when feedback is provided in an alternating fashion instead of all feedback at once (Schulz, 2013). Furthermore, complementing brief interventions with cue reminder strategies or prototype alteration may increase follow-up rates (van Lettow, 2015). These characteristics are largely supported by the literature, which shows a significant contribution on treatment completion of treatment readiness, gender, education level, age, baseline alcohol consumption and readiness to change (Postel et al., 2011).

It is important that future research focuses on ways in which attrition can be reduced to a minimum, considering that attrition can cause biased estimates of the effects of interventions, it can reduce the statistical power and limit the generalizability of results (Leon et al., 2005). Specifically in randomized trials, participant dropout may result in attrition bias ('differential attrition'), resulting in an imbalance between the previously randomized, 'equally divided' groups (Leon et al., 2005). This complicates the interpretation of results and threatens the internal validity of a RCT (Leon, et al., 2005). For example, in the study by Kypri et al (2014) the researchers initially found an intervention effect on the number of drinks consumed per typical drinking occasion, which was no longer statistically significant following sensitivity analysis accounting for attrition.

Drinking refusal self-efficacy

Voogt (2014b) conducted an additional randomized controlled trial on the same sample as included in the present study (Voogt, 2013b; 2014a), aiming to determine the effect of the intervention on drinking refusal self-efficacy (DRSE). Three DRSE states are distinguished; drinking related to emotional relief, to opportunity, and to social pressure. High drinking refusal self-efficacy is associated with reduced alcohol use. The study showed that participants in the experimental condition perceived higher social pressure DRSE compared to control at six-months follow-up. Additionally, DRSE was negatively related to WAC, and social pressure DRSE to frequency of HED. The WDYD intervention did not affect the strength of these relationships. The intervention increased social pressure DRSE directly after intervention, which was sustained at follow-up. This increase is likely responsible for the sustained preventive effects of the intervention. Therefore, future trials (targeting adolescent drinkers) should aim to increase participants' drinking refusal self-efficacy, particularly DRSE related to social pressure.

Ethics of trial design

Several trials were included with treatment seeking participants, such as those seeking to achieve and maintain abstinence. In these studies, the control condition received treatment as usual while the intervention group received the intervention in addition to treatment as usual. These studies found no intervention effects, which they may have when the intervention would have been compared with an assessment only control group. However, it can be argued that it is unethical to place patients seeking treatment for problematic alcohol use in an assessment only control condition. This problem was observed in the consecutive studies by Hester (2013) and Campbell (2016), which originally aimed for a three arm trial with one SMART recovery group (TAU), one SR + the online extension Overcoming Addictions, and one Overcoming Addictions only group. However, the trial could not be conducted with the latter group due to ethical considerations. One potential solution would be to conduct this type of trial with non-treatment seeking people with problematic alcohol consumption that have been identified via screening. For example, the student health

services ('Bureau Studentenartsen') has developed the StudentHealthCheck¹ ('Studentengezondheidstest'). This may offer a feasible platform for the identification of problematic alcohol users without a primary care request, thereby circumventing ethical considerations and 'paving the way' for improved trial design and execution.

Strengths and limitations

The present study provides a comprehensive overview of the effectiveness of ehealth applications targeting problematic alcohol use. This review differs from other reviews in that it includes both adolescents and adults, diverging drinking behaviours and intervention types. Other reviews exist, but narrow their scope by reviewing mobile interventions targeting risky drinking among university students (Berman *et al.*, 2016), focus on broader mental healthcare than only alcohol use disorders, (McKay, Cheng *et al.*, 2016), are reviews of reviews (Sundstrom *et al.*, 2016) or are somewhat outdated considering the rapidly evolving field (Bewick *et al.*, 2008; Khadjesari *et al.*, 2011; Riper *et al.*, 2011; Stoner *et al.*, 2011). As such, the present review is for as far is known the only recent review evaluating effectiveness that includes both adolescents and adults, both web- and smartphone-based interventions, and problematic as well as non-problematic alcohol consumption.

Narrative reviews tend to be mainly descriptive and often focus on certain studies based on availability and author selection, making them prone to an element of selection bias (Uman, 2011). On the other end, systematic literature reviews typically involve a detailed and comprehensive plan, aiming to reduce this bias by identifying, appraising and synthesizing all relevant studies on a particular topic (Uman, 2011). Multiple search syntaxes were developed and forward- and backward-citation tracking was performed to increase the potential number of studies for inclusion. However, only one database was included and future reviews adopting the same strategy will likely end up with a somewhat different final article selection. It can therefore be argued that the present study is prone to a certain degree of selection bias, which is a limitation. Furthermore, it may be that the study is prone to a certain investigator bias, since only one researcher conducted the review. Cross-checking and verifying the selection and interpretation of data by multiple researchers (e.g. investigator triangulation) can decrease the potential bias in gathering, reporting or analyzing of the data and contribute to the internal validity of a study (Thurmond, 2001). However, careful reading and rereading of the studies under review and double-checking the findings with the original studies was performed to decrease the risk of bias and increase the validity of the results.

Future research

- Most ehealth interventions were put forward as being personalized, which generally referred to personalization of name and the comparison with peers. However, ehealth interventions can potentially be personalized further, for example on the basis of age, sex, screening outcomes, patient characteristics, participants' drinking-refusal self-efficacy, and their level of response to alcohol. Increased personalization and modification to user characteristics is expected to increase intervention effectiveness and duration of these effects even further.
- No studies compared a stand-alone digital intervention with treatment as usual. This is desirable since it would enable researchers to determine the relative effectiveness of a digital intervention compared to treatment as usual. As of yet, studies compare an intervention with an assessment-only control condition or complement treatment as usual with an ehealth intervention. Although this does tell us something, it does not answer the question how effective ehealth interventions actually are in comparison to treatment as usual. It is therefore important that future research address this knowledge gap.

¹ <http://www.studentengezondheidstest.nl/en> Retrieved on 27/01/2016

- Randomized controlled trials should where possible apply ecological momentary assessment and/or multiple follow-up time-points to take fluctuations in alcohol use into account, thereby avoiding potentially false conclusions on intervention effectiveness.
- Increasingly, scientifically grounded smartphone applications should be developed and tested. Currently, the majority of interventions are brief web-based interventions, which should diversify.
- More complex and diverse interventions. Many brief interventions are available, the majority focusing on brief personalized normative feedback and motivational interviewing techniques. As of yet, few interventions test the effectiveness of cognitive behavioural therapy and cognitive bias modification. No trials were identified that assessed the effectiveness of online mutual help groups or behavioural self-control training. This should diversify.
- Only one study (Voogt et al., 2013a) targeted people with a lower education background. Despite the fact that language was adapted to the target audience, the intervention was not effective for any of the six outcome measures. Therefore, future research is needed to determine the underlying factor for the difference in effectiveness between people with a high- and a low education in order to develop effective interventions for the latter subgroup.
- It became clear that interventions combining social norms information (PNF) and motivational aspects were generally more effective than providing either one type as a stand-alone intervention. Future research should increasingly develop somewhat less brief interventions that combine multiple intervention types. This is not necessarily limited to PNF and motivational interviewing, but can also involve decisional balance feedback, cognitive behavioural therapy and cognitive bias modification.

Conclusion

The present study aimed to provide a comprehensive overview of the effectiveness of ehealth interventions to complement or partially replace conventional care at general practices regarding the problematic use of alcohol, by reviewing the scientific literature for evidence of ehealth interventions in light of the problematic use of alcohol. Two sub-questions were derived from the main research question:

1) Are digital interventions more effective than no intervention?

Multiple interventions were significantly more effective than assessment-only control groups in reducing alcohol consumption. Here, convincing evidence was found for interventions adopting both normative feedback as well as a motivational interviewing approach, while none of the interventions adopting only one of these approaches found significant differences in effectiveness. Also, normative feedback interventions were more effective when complemented with additional strategies such as prototype alteration and cue reminders. Other intervention types that showed effectiveness were based on cognitive behavioural self-help and decisional balance feedback.

Overall, both brief interventions and more extensive interventions can reduce alcohol consumption among adolescents and adults with problematic alcohol consumption in high income countries. Effects are generally small and persist mostly on the short- to medium-term. Nonetheless, they may still result in substantial health gains considering that they can reach many people that would otherwise not seek help. They offer a low threshold alternative that people can conduct anonymously, in their own time, on their own pace and on a location that suits them best. Ehealth interventions can contribute to the self-management of people assessing those interventions through their own interest and motivation. Not all digital interventions are more effective than no intervention and intervention should therefore be prescribed based on proven effectiveness. In the Dutch setting, the 'What-do-you-drink' ('www.watdrinkij.nl) website can be recommended to heavy drinking students. Furthermore, the drinktest intervention (www.drinktest.nl) can be recommended for heavy drinking adults.

2) Are digital interventions equally or more effective than care as usual?

There was limited evidence that digital interventions are more or equally effective than care as usual. None of the studies under review compared an ehealth intervention group with care as usual group, while several studies provided an ehealth intervention on top of care as usual. One study found a significant reduction in the number of risky drinking days among participants that received a smartphone application on top of care as usual in comparison to participants only receiving care as usual. Importantly, most studies complementing care as usual with a digital intervention found a reduction in alcohol consumption in all groups. This makes it impossible to draw conclusions as to whether or not digital interventions are equally or more effective than care as usual. There is, as of yet, no evidence that ehealth can (partially) replace care as usual in terms of effectiveness. The A-CHES smartphone app can be used to complement care as usual for patients leaving residential treatment. There is a need for studies comparing stand-alone ehealth interventions with treatment as usual.

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Appendix 1: Search syntaxes

First syntax: N=130 hits.

((("randomised controlled trial"[tiab] OR "RCT"[tiab] OR ("Randomized Controlled Trial" [Publication Type] OR "Randomized Controlled Trial"[tiab])) AND ("alcoholism"[mesh] OR "alcohol*"[tiab] OR "sobriety"[tiab] OR "sober"[tiab])) AND ("Telemedicine"[Mesh:NoExp] OR "mHealth"[tiab] OR "mobile health"[tiab] OR "eHealth"[tiab] OR "telemedicine"[tiab] OR "mobile application*"[tiab] OR "mobile device"[tiab] OR "web-based"[tiab] OR "smartphone*"[tiab])) AND ("last 5 years"[PDat]) NOT "study protocol"[tiab])

Second syntax: N= 60 hits

("alcoholism"[mesh] OR "alcohol*"[tiab] OR "sobriety"[tiab] OR "sober"[tiab]) AND ("Telemedicine"[Mesh:NoExp] OR "mHealth"[tiab] OR "mobile health"[tiab] OR "eHealth"[tiab] OR "telemedicine"[tiab] OR "mobile application*"[tiab] OR "mobile device"[tiab] OR "web-based"[tiab] OR "smartphone*"[tiab]) AND ("Self Care"[Mesh:NoExp] OR "self care"[tiab] OR "self-management"[tiab] OR "empowerment"[tiab] OR "General Practitioners"[Mesh] OR "primary care physician*"[tiab] OR "primary care"[tiab] OR "general practitioner*"[tiab] OR "general practice"[tiab]) AND ("last 5 years"[PDat])