

# Identifying Effective Behavior Change Techniques for Alcohol and Illicit Substance Use During Pregnancy: A Systematic Review

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## Abstract

**Background** During pregnancy, consuming alcohol and using illicit drugs can have serious health implications for both mother and child. Behavioral change interventions, especially those underpinned by theoretical constructs, can be effective in reducing harmful substance use among pregnant women.

**Purpose** To understand what type of behavior change mechanisms could be useful in reducing alcohol consumption or achieving abstinence from illicit drug use during pregnancy, this review aimed to identify behavior change techniques (BCTs), the smallest, active components of interventions that may be effective. It also aimed to establish the extent that psychosocial-based theories were used to inform intervention design.

**Methods** To identify eligible randomized controlled trials (RCTs), five databases were searched electronically from the end search dates of the most recent Cochrane systematic reviews on behavioral interventions for each behavior, until March 2018. Within the RCTs, intervention descriptions were analyzed for BCT content and extent of theory use in the intervention design process and outcome measurements, in each trial, was established. “Effectiveness percentages,” the number of times a BCT had been a component of an effective intervention divided by the total number of interventions it had been used in, were calculated for BCTs used in two or more trials.

**Results** Including all RCTs from the Cochrane reviews, and those published subsequently, nine alcohol and six illicit drug trials were identified. Interventions tested in four alcohol RCTs and no illicit drugs RCTs showed positive results. Subsequent data were extracted for alcohol consumption trials only. Thirteen BCTs showed “potential effectiveness” for alcohol consumption. Six of nine included alcohol trials reported using theory but not extensively.

**Conclusions** Action planning, behavioral contract, prompts/cues, self-talk, offer/direct toward written material, problem solving, feedback on behavior, social support (unspecified), information about health consequences, behavior substitution, assess current readiness and ability to reduce excess alcohol consumption, goal setting (behavior), and tailor interactions appropriately are BCTs that could be useful in helping reduce alcohol consumption among pregnant women.

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## Introduction

Excessive alcohol consumption [1] and illicit drug use [2] account for a considerable proportion of chronic illness and health care expenditure in higher income countries [1]; in pregnancy, these lifestyle factors pose considerable health risks to both mother and baby. Alcohol consumption is directly linked to fetal alcohol syndrome and is known to increase the risks of stillbirth, spontaneous abortion, premature birth, and low birthweight [3]. Similarly, illicit drug use can result in low birth weight, feeding difficulties, and stunted development both physically and cognitively [4]. Furthermore, women who consume one of these substances during pregnancy are more likely to consume at least one other substance [5]. Many national guidelines now advocate abstinence from alcohol and illicit drugs during pregnancy [6–11].

Despite pregnancy being a powerful motivator to engage in health-enhancing behaviors [12], many women continue to use alcohol and illicit drugs throughout pregnancy. Up to 80% of pregnant women in Ireland, and  $\geq 40\%$  in the UK, Australia, and New Zealand, are known to drink alcohol, with high levels of binge drinking [8]. In the USA, alcohol use in pregnancy has gradually increased over the past three decades [11]. Currently, 6% of U.S. pregnant women use illicit drugs, which is similar to prevalence in Europe and Australia [13].

Midwives and other health professionals providing antenatal care are in a good position to promote behavior change toward healthier lifestyle practices, in the attempt to reduce these harmful behaviors during pregnancy [14]. Cochrane reviews have shown that evidence-based behavioral change interventions can be effective during pregnancy [11, 15]; however, this evidence was inconsistent which is a finding reflected in subsequent work [16]. It would therefore seem important to investigate further what could make behavioral change interventions, aimed to reduce alcohol and drug use during pregnancy, effective.

It is possible that previous work has found inconsistencies as they have assessed interventions at the general level of function, which is the method through which the intervention aims to change behavior [17] (e.g., education [15]) or categorize them into an intervention type (e.g., psychosocial [11]) rather than consider the underlying, individual, active components of the interventions known as behavior change techniques (BCTs) [18, 19]. By analyzing interventions at this more fundamental level of the individual components contained within them, it is likely to give a more in-depth understanding of the underlying mechanisms required to change behavior [20]. In addition to intervention content, another important aspect to behavioral change intervention design is the use of psychosocial-based theories [21, 22].

This can inform BCT choice, indicate which BCTs might work in conjunction with each other [23–25] and has been found to increase the general effectiveness of interventions [23, 26]. As such guidelines advocate, that theory is incorporated at all stages in the design process for behavioral change interventions [21, 22].

The main aim of this review was to identify BCTs that have been used in effective behavioral support interventions for reducing alcohol consumption and illicit drugs use among pregnant women. A secondary aim was to determine whether theory was used and if so, to what extent in the intervention studies.

## Methods

### Search Strategies

We used the same search strategies as the most recent Cochrane systematic reviews [11, 15] (see [Supplemental File 1](#)). To ensure all trials published after the most recent Cochrane reviews were identified, searches were carried out in PubMed, Cinahl, PsycInfo, Cochrane Library (CENTRAL), and EMBASE databases from the date of search completion of each review (alcohol: 2007, illicit drugs: 2015) until March 2018.

### Inclusion Criteria

Studies had to be randomized controlled trials (RCTs) or cluster RCTs that delivered behavioral support interventions to pregnant women who consumed alcohol or used illicit drugs. Outcomes were self-reported or biochemically validated: abstinence or reduction in alcohol consumption and abstinence for illicit drug use. Studies with more than one intervention group, where one or more groups received behavioral support only and one group received no intervention or “usual care” (control group) were also included. As previously described, to establish which individual BCTs could be particularly effective [27], control groups had to receive no intervention or “usual care.”

### Exclusion Criteria

Studies were excluded if they did not enroll pregnant women or if they only reported physiological outcome measures for maternal or neonatal health.

### Outcomes

#### *Alcohol*

Due to international and temporal variation in recommendations for safe drinking in pregnancy, outcomes in

alcohol studies varied over time and across countries. In Scotland, Ireland, USA, Canada, Australia, and New Zealand, for example, guidelines consistently advocate abstinence only, with no amount of alcohol thought to be safe throughout pregnancy [6, 8–10, 28, 29]. In England, although the guidelines now advocate abstinence only [7], prior to 2016, recommendations were such that abstinence was preferable, but if not achievable then one to two drinks, once or twice a week without getting drunk, was the upper recommended limit to avoid fetal risks [30]. Consequently, we used outcomes of either abstinence or reduction in alcohol consumption.

### *Illicit drugs*

As no evidence has yet been found to show there are any safe limits for nonprescription drug use in pregnancy [31], the outcome used for illicit drugs was abstinence only.

### *Effectiveness criteria and percentages for BCTs*

We sought to identify BCTs that had been used in “effective” interventions. For an intervention to be considered effective, trials needed to demonstrate an odds ratio (OR) in favor of the intervention being effective, which was statistically significant at the 5% level (i.e., OR > 1.0, with 95% confidence intervals, where the lower limit is >1.0 or a *p* value of <.05).

An “effectiveness percentage,” a measure to reflect potential effectiveness, was calculated for all identified BCTs. This was the number of times a BCT had been a component of an effective intervention, divided by the total number of interventions in which the BCT had been a component, expressed as a percentage. For the “effective percentages” to be meaningful, they were only calculated for BCTs that had been used as components of interventions in two or more trials. This follows methods used in similar research [32].

### *Risk of bias assessment*

A risk of bias assessment, using the Cochrane criteria [33], was conducted for trials that had not already had this done for a published review; otherwise published bias assessments were used [11, 15].

### *Data extraction*

To maximize the information on BCTs, we requested study protocols and intervention manuals for all eligible studies.

### *Study characteristics*

We extracted the following data: country where conducted, study design, intervention type, delivery setting,

who delivered the intervention, sample size, outcome measure type, BCT content, and whether and, if so, to what extent theory was integrated.

### *BCTs identification*

There is a taxonomy that describes BCTs for alcohol consumption [34] but not one that describes BCTs that might minimize illicit drug use. However, since the production of behavior-specific taxonomies, a comprehensive and more generic BCT taxonomy (BCTTv1) [35] intended for use with any type of behavior change has been produced. Together, these taxonomies inform behavior change intervention design and can also be used to identify BCT content in existing interventions [25]. The BCTTv1 [35] contains 93 BCTs in total and although the alcohol taxonomy [34] contains 40 BCTs, 28 of these are covered in the BCTTv1 [35]. Therefore, for the purposes of BCT identification, we used the 93 BCTs from the BCTTv1 [35] in addition to the 12 from the alcohol taxonomy [34] that are not covered in the BCTTv1 [35] (listed in [Supplemental File 2](#)). Prior to coding the BCTs, all coders (L.F., T.C.-H., & K.A.C.) undertook online training in BCT recognition [36]. For all included studies, two researchers (L.F. & T.C.-H.) independently identified the text describing contents of the behavioral interventions from published papers and from study protocols or intervention manuals where available. Any identified BCTs were coded and interrater reliability per intervention was described using Cohen’s Kappa statistic [37], calculated using SPSS v22. Subsequently, any discrepancies were resolved through discussion.

### *Theory identification*

To establish to what extent each trial had incorporated theory, two researchers (L.F. & T.C.-H.) used a previously described coding continuum [38] which has four stages: (a) informed by theory—there was mention of theory but no evidence of the use of any of its constructs in the intervention or outcome measures; (b) applied theory—one or more of the mentioned theoretical constructs had been applied to components of the study; (c) testing theory—at least half of the mentioned theoretical constructs had been tested or a comparison had been made between two theories within the study; and (d) building on theory—either a new theory had been developed or an existing theory had been expanded on the basis of the results.

Although motivational interviewing (MI) is a technique rather than a theory, as it has evidence-based theoretical underpinnings [39], it was classified as a theory for the purposes of this review.

## Results

### Search Results

#### *Alcohol*

A total of 379 papers were identified of which 262 were duplicates and so removed. Following title and abstract screening, 106 of the 117 studies were considered irrelevant as they used no behavioral intervention and/or were not RCTs. We retrieved 11 full texts; one was excluded as it was a secondary analysis [40] and one had used arbitrary rather than randomized allocation [41], leaving nine included RCTs [42–50]. Five of these nine RCTs [42, 46, 48–50] were not included in the Cochrane review [15] (see Fig. 1 for PRISMA flow diagram [51]). Four RCTs [44, 45, 47, 49] had effective interventions.

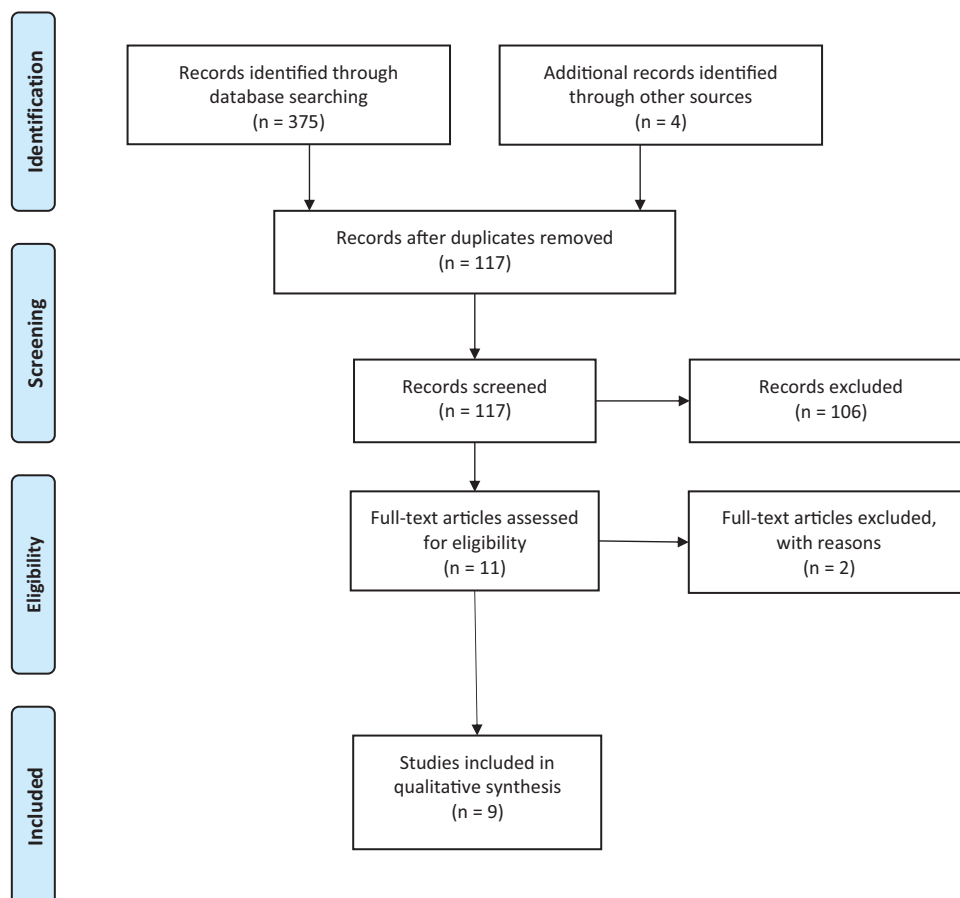
#### *Illicit drug use*

A total of 304 papers were identified of which 246 were duplicates and so removed. After title and abstract screening, 50 of the 58 studies were considered irrelevant

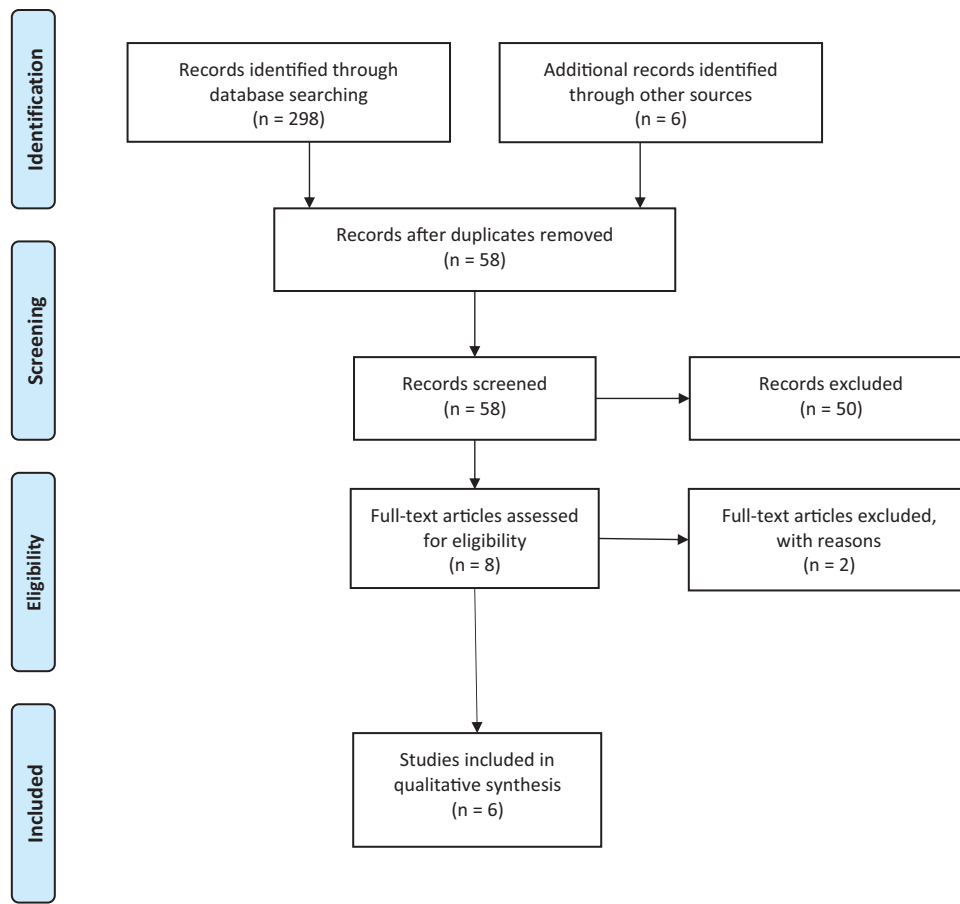
as they used no behavioral-based interventions and/or were not RCTs. We retrieved eight full texts; one study was removed as it measured retention to treatment only as an outcome [52]; another primarily measured retention to treatment, and reduction in substance use, not abstinence, as a secondary outcome [53]. This left six RCTs [54–59], all of which were in the Cochrane review [11] (see Fig. 2 For PRISMA flow diagram [51]). None had effective interventions, and therefore, there was no further data extraction or analysis carried out on these studies.

#### *Risk of bias assessment*

Four papers [43–45, 47] had already been bias-assessed for the Cochrane review [15] and so five [42, 46, 48–50] were assessed for this review (see Supplemental File 3). The risk of bias for allocation concealment, incomplete outcome data, and selective reporting, in all of the nine included papers, was generally unclear, mainly due to lack of information. The blinding of outcome risk of bias assessment was mixed, and there was a high risk of bias for blinding of participants and personnel in all but one paper [48]. Random sequence generation was usually



**Fig. 1.** Identification of eligible randomized controlled trials aimed to reduce alcohol consumption during pregnancy. Flow chart taken from PRISMA Statement (2009) [52].



**Fig. 2.** Identification of eligible randomized controlled trials aimed to achieve illicit drug abstinence during pregnancy. Flow chart taken from PRISMA Statement (2009) [52].

well described and other bias was mixed mainly between low and unclear, although it was high in one paper [50].

### Study characteristics

Eight trials were standard RCTs [42–48, 50], and one was a cluster RCT [49]. Seven were conducted in the USA [42–48], one in the Netherlands [49], and one in the UK [50]. The types of interventions were digital [48], brief [42, 43, 45], self-help [47], counseling [49, 50], and MI [44, 46]. One was technology delivered [48], two were delivered by researchers [44, 46], five by various health care professionals [42, 43, 45, 49, 50], and instruction was given by an educator in one [47]. Seven were delivered face-to-face on a one-to-one basis, once only [42–44, 46, 50]; one of these studies supplied extra written materials [45] and one provided a self-help manual [52]. One was delivered by a computer, once only [48]. Sample sizes were intervention  $n = 123$ , control  $n = 127$  [43]; intervention  $n = 152$ , control  $n = 152$  [42]; intervention  $n = 16$ , control  $n = 18$  [44]; intervention  $n = 182$ , control  $n = 162$  [45]; intervention  $n = 62$ , control  $n = 60$  [46]; intervention  $n = 42$ , control  $n = 36$  [47]; intervention  $n = 27$ , control  $n = 23$  [48]; intervention 1  $n = 135$ , intervention 2

$n = 116$ , control  $n = 142$  [49]; intervention 1  $n = 559$ , control 1  $n = 477$ , intervention 2  $n = 500$ , control 2  $n = 564$  [50]. Two of the trials reported carrying out sample size calculations prior to the trial commencing [42, 49]. All nine studies used self-reported outcome measures [42–50]. One had used the “bogus pipeline” method in addition to self-reports [47], which meant that in the attempt to minimize underreporting of consumption, the women were falsely informed that routine blood and urine samples would be tested for alcohol. All interventions were conducted in clinical settings [42–50] (Table 1).

### Identification of BCTs

Extra material was provided by two authors of the included alcohol studies [45, 47]. One was the workbook that had been issued to participants [45], and one was a final study progress report [47]. In six of the alcohol studies, the authors had selected BCTs in line with the theory used [44–49], and in three, they had selected the BCTs on the basis of what had already been shown to be effective [42, 43, 50]. A total of 26 BCTs were found in interventions for alcohol consumption reduction (Table 2), 13 of which were in two or more trials (Table 3). These 26 BCTs

**Table 1** Study characteristics of included alcohol reduction randomized controlled trials

| References          | Country | Study design | Intervention type  | Delivery setting & delivered by   | Number of participants                                      | Theory reported  | BCTs used   | Outcome measure type | Positive outcome |
|---------------------|---------|--------------|--|---|---|--|---|----------------------|------------------|
| Chang 1999 [43]     | USA     | RCT          | Brief intervention   | Clinic & obstetric practices<br>Professor in Psychiatry (first author). | Intervention<br><i>n</i> = 123<br>Control<br><i>n</i> = 127 | None reported  | 1.1 Goal setting (behavior)<br>1.2 Problem solving<br>4.2 Information about antecedents<br>8.2 Behavior substitution<br>9.1 Credible source<br>30. Offer/direct toward appropriate written materials                              | Self-reported        | N                |
| Chang 2005 [42]     | USA     | RCT          | Brief intervention including partner                                     | Hospital<br>Nurse practitioner or Principal Investigator                | Intervention<br><i>n</i> = 152<br>Control<br><i>n</i> = 152 | None reported  | 1.1 Goal setting (behavior)<br>1.2 Problem solving<br>1.8 Behavioral contract<br>8.2 Behavior substitution<br>31. Assess current and past drinking behavior<br>40. Elicit and answer questions                                    | Self-reported        | N                |
| Handmaker 1999 [44] | USA     | RCT          | Motivational interviewing (MI) techniques used                           | Obstetric clinics<br>Researcher   | Intervention<br><i>n</i> = 16<br>Control<br><i>n</i> = 18   | Motivational interviewing principles                             | 2.2 Feedback on behavior<br>3.1 Social support (unspecified)<br>5.1 Information about health consequences<br>29. Assess current readiness and ability to reduce excessive alcohol consumption                                     | Self-reported        | Y                |
| O'Connor 2007 [45]  | USA     | RCT          | Brief Intervention   | Women, Infants and Children Centres<br>Nutritionist                     | Intervention<br><i>n</i> = 182<br>Control<br><i>n</i> = 162 | Social learning theory   | 1.1 Goal setting (behavior)<br>1.2 Problem solving<br>1.8 Behavioral contract<br>3.1 Social support (unspecified)<br>5.1 Information about health consequences<br>8.2 Behavior substitution<br>8.7 Graded tasks<br>15.4 Self-talk | Self-reported        | Y                |
| Osterman 2014 [46]  | USA     | RCT          | Motivational Interviewing & Self-determination theory based intervention | University Medical Centre<br>Researcher                                 | Intervention<br><i>n</i> = 62<br>Control<br><i>n</i> = 60   | Motivational interviewing principles & Self-determination theory | 1.6 Discrepancy between current behavior and goal<br>2.2 Feedback on behavior<br>3.1 Social support (unspecified)<br>5.1 Information about health consequences  | Self-reported        | N                |

**Table 1** (Continued)

| References             | Country     | Study design | Intervention type   | Delivery setting & delivered by  | Number of participants   | Theory reported  | BCTs used  | Outcome measure type                                   | Positive outcome |
|------------------------|-------------|--------------|---|--|--|--|--|--|------------------|
| Reynolds 1995 [47]     | USA         | RCT          | Self-help in tervention   | Clinic Instruction on how to perform the intervention was provided by an educator    | Intervention <i>n</i> = 42<br>Control <i>n</i> = 36  | Cognitive-behavioral Theory                                    | 1.1 Goal setting (behavior)<br>1.2 Problem solving<br>1.4 Action planning<br>2.3 Self-monitoring of behavior<br>3.1 Social support (unspecified)<br>5.1 Information about health consequences<br>7.1 Prompts/cues  | Self-reported<br>The “bogus pipeline” method also used | Y                |
| Tzilos 2011 [48]       | USA         | RCT          | Computer-delivered motivational intervention  | Pre-natal care clinic Computer-delivered   | Intervention <i>n</i> = 27<br>Control <i>n</i> = 23  | Motivational interviewing principles<br>Stages of change model | 1.1 Goal setting (behavior)<br>1.2 Problem solving<br>3.1 Social support (unspecified)<br>5.1 Information about health consequences<br>6.2 Social comparison<br>9.2 Pros and cons<br>29. Assess current readiness and ability to reduce excessive alcohol consumption<br>35. Tailor interactions appropriately   | Self-reported  | N                |
| van der Wulp 2014 [49] | Netherlands | Cluster RCT  | Health Counselling (Intervention 1) Computer-tailored feedback (Intervention 2)   | Midwife practices Health Counselling: Midwives Tailored feedback: computer-delivered | Intervention 1 <i>n</i> = 135<br>Intervention 2 <i>n</i> = 116<br>Control <i>n</i> = 142                               | I-Change model   | 1.1 Goal setting (behavior)<br>1.2 Problem solving<br>1.4 Action planning<br>2.2 Feedback on behavior<br>3.1 Social support (unspecified)<br>5.1 Information about health consequences<br>7.1 Prompts/cues<br>29. Assess current readiness and ability to reduce excessive alcohol consumption<br>31. Assess current and past drinking behavior<br>35. Tailor interactions appropriately | Self-reported  | Y                |
| Waterson 1990 [50]     | UK          | RCT          | Provision of written information & verbal reinforcement<br>Provision of written information, verbal reinforcement & video | Antenatal clinic Doctor  | Intervention 1 <i>n</i> = 559<br>Control 1 <i>n</i> = 477<br>Intervention 2 <i>n</i> = 500<br>Control 2 <i>n</i> = 564 | None reported  | 5.1 Information about health consequences<br>9.1 Credible source<br>30. Offer/direct toward appropriate written materials  | Self-reported  | N                |

*BCT* behavior change technique; *RCT* randomized controlled trial.

account for 25% of the 105 BCTs described in the alcohol-specific and BCTTv1 taxonomies combined [34, 35]. The 79 BCTs that were not found in any of the interventions are listed in [Supplemental File 4](#).

#### *Inter-rater reliability for identification of BCTs per intervention*

For the interventions in the nine included alcohol studies, there was substantial agreement (kappa, 0.61–0.80) [60] for BCT coding in four [43, 45, 47, 49] (44%), moderate agreement (kappa, 0.41–0.60) [60] for four [44, 46, 48, 50] (44%), and none to slight agreement (kappa, 0.01–0.20) [60] for one [42] (11%) of the interventions. For those that had moderate and none to slight agreement, discrepancies in coding were resolved through discussion. This involved two researchers (L.F. & T.C.-H.) re-reading the text that described the relevant BCTs, comparing it with the descriptions of the closest fitting BCTs from the relevant taxonomy and reaching

agreement on which it should be coded as. As agreement was not reached on the coding of the BCTs in one trial [42] at that stage, a third researcher (K.C.) was consulted.

#### *Effectiveness percentages for BCTs*

Of the BCTs that were components of two or more alcohol reduction interventions, five—action planning, behavioral contract, prompts/cues, self-talk, and offer/direct toward appropriate written materials—had 100% effectiveness percentages. Six had effectiveness percentages of 67%: problem solving, feedback on behavior, social support (unspecified), information about health consequences, behavior substitution, and assess current readiness and ability to reduce excessive alcohol consumption. Two had effectiveness percentages of 50%: goal setting (behavior) and tailor interactions appropriately ([Table 3](#)).

**Table 2** Behavior change techniques that were found within the interventions from all included randomized controlled trials

| BCT number        | BCT label BCTTv1 [35]   | n (%) of interventions found within alcohol |
|-------------------|---|---|
| 1.1               | Goal setting (behavior)   | 6 (67)                                      |
| 1.2               | Problem solving   | 6 (67)                                      |
| 1.4               | Action planning   | 2 (22)                                      |
| 1.6               | Discrepancy between current behavior and goal                                       | 1 (11)                                      |
| 1.8               | Behavioral contract   | 2 (22)                                      |
| 2.2               | Feedback on behavior  | 3 (33)                                      |
| 2.3               | Self-monitoring of behavior   | 1 (11)                                      |
| 3.1               | Social support (unspecified)  | 6 (67)                                      |
| 4.2               | Information about antecedents   | 1 (11)                                      |
| 5.1               | Information about health consequences   | 6 (67)                                      |
| 6.2               | Social comparison   | 1 (11)                                      |
| 7.1               | Prompts/cues  | 2 (22)                                      |
| 8.2               | Behavior substitution   | 3 (33)                                      |
| 8.7               | Graded tasks  | 1 (11)                                      |
| 9.1               | Credible source   | 2 (22)                                      |
| 9.2               | Pros and cons   | 1 (11)                                      |
| 9.3               | Comparative imagining of future outcomes  | 1 (11)                                      |
| 10.9              | Self-reward   | 1 (11)                                      |
| 12.1              | Restructuring the physical environment  | 1 (11)                                      |
| 12.3              | Avoidance/reducing exposure to cues for the behavior                                | 1 (11)                                      |
| 15.4              | Self-talk   | 2 (22)                                      |
| <b>BCT number</b> | <b>BCT label: alcohol specific BCTs [34] that did not map on to the BCTTV1 [35]</b> |   |
| 29                | Assess current readiness and ability to reduce excessive alcohol consumption        | 3 (33)                                      |
| 30                | Offer/direct toward appropriate written materials                                   | 2 (22)                                      |
| 31                | Assess current and past drinking behavior   | 2 (22)                                      |
| 35                | Tailor interactions appropriately   | 2 (22)                                      |
| 40                | Elicit and answer questions   | 1 (11)                                      |

*BCT* behavior change technique.



**Table 3** Effectiveness percentages for behavior change techniques found within two or more alcohol interventions

| BCT number & taxonomy label   | Number of effective trials used in | Total number of trials used in | Effectiveness percentage |
|---|------------------------------------|--------------------------------|--------------------------|
| 1.4. Action planning (BCTTv1 [35])  | 2                                  | 2                              | 100%                     |
| 1.8. Behavioral contract (BCTTv1 [35])  | 2                                  | 2                              | 100%                     |
| 7.1. Prompts/cues (BCTTv1 [35])   | 2                                  | 2                              | 100%                     |
| 15.4 Self-talk (BCTTv1 [35])  | 2                                  | 2                              | 100%                     |
| 30. Offer/direct towards appropriate written materials (alcohol taxonomy [34])                          | 2                                  | 2                              | 100%                     |
| 1.2 Problem solving (BCTTv1 [35])   | 4                                  | 6                              | 67%                      |
| 2.2 Feedback on behavior (BCTTv1 [35])  | 2                                  | 3                              | 67%                      |
| 3.1 Social support (unspecified) (BCTTv1 [36])  | 4                                  | 6                              | 67%                      |
| 5.1 Information about health consequences (BCTTv1 [35])   | 4                                  | 6                              | 67%                      |
| 8.2 Behavior substitution (BCTTv1 [35])   | 2                                  | 3                              | 67%                      |
| 29 Assess current readiness and ability to reduce excessive alcohol consumption (alcohol taxonomy [34]) | 2                                  | 3                              | 67%                      |
| 1.1 Goal setting (behavior) (BCTTv1 [35])   | 3                                  | 6                              | 50%                      |
| 35 Tailor interactions appropriately (alcohol taxonomy [35])  | 1                                  | 2                              | 50%                      |

### Theory identification

In relation to the four-stage coding continuum [38], six [44–49] of the nine included trials were informed by theory; this included the four with effective interventions [44, 45, 47, 49]. Three of the six reported using MI principles [44, 46, 48], two of which also used one other theory: self-determination theory [46] and stages of change model [48]. Two used social cognition theories [45, 47], and one used the I-Change model [49] (see Table 1). Four had applied theory [44, 46, 47, 49], two [46, 47] tested theory, and none attempted theory development.

### Discussion

This review identified 13 potentially effective BCTs that have been used in behavioral change interventions to reduce alcohol consumption during pregnancy. There were no effective interventions for illicit drug use. Few potential BCTs from the BCTTv1 [35] and alcohol taxonomy [34] combined that could have been used were included in the alcohol reduction interventions. Of the RCTs included in the final analysis for alcohol consumption, fewer than half reported using theory and, of those that did, most were informed by theory only.

While reviews of this type usually focus on one behavior [61, 62], by including two related behaviors, which often happen concurrently with one another, this study offers a more comprehensive overview of what has or has not been effective for reducing substance misuse during pregnancy. Ensuring all coders undertook online BCT coding training [36] and using relevant, evidence-based BCT taxonomies [34, 35] to produce the coding template

helped strengthen the validity and reliability of coding. This was reflected in the high level of inter-rater reliability. Rather than simply assessing whether or not theory had been used, as previous reviews have done [23], we used a continuum framework [38] which provided better insight into the extent and nature of theory use. There are other, more detailed, frameworks such as the 19-item Theory Coding Scheme [26]; however, the four-item framework used [38] was deemed sufficient for the purposes of this review considering the lack of detail on the theory used within the included RCTs.

There were several limitations to this review. Typically, behavior change interventions contain several BCTs that are thought to interact with each other to achieve the desired outcome [25]. As potential effectiveness was only assessed for individual BCTs, it was not possible to ascertain whether positive results achieved by the effective interventions were due to certain combinations of BCTs. However, as BCT content varied across interventions, assessing potential effectiveness for each BCT individually, which has been done previously with similar justification [20, 24], was thought to be the most pragmatic approach. Analyzing at this level also highlighted the large proportion of BCTs that had not been included in any of the interventions, but could be potentially relevant and effective for use in future interventions.

The risk of bias in relation to blinding of participants and personnel was high in the majority of RCTs included in the final analyses. Only two trials reported calculating sample size required prior to running the study [42, 49] and some had relatively small sample sizes [44, 46–48]. It is therefore possible that some of the trials did not have positive results due to being underpowered rather than the interventions not being effective [63]. In addition, all

included alcohol studies [42–50] relied on self-reported outcomes only without any biochemical validation; therefore, positive results could have been boosted by the social desirability effect [27]. As such, some of our conclusions about the potential effectiveness of BCTs may be based on biased treatment effect estimates, and so it is an important consideration when interpreting the results or drawing conclusions [64].

The finding that relatively few BCTs were tested across the interventions for alcohol is mirrored by findings from reviews of interventions for alcohol intake reduction in nonpregnant populations [25]. Including a larger number of BCTs does not necessarily make an intervention more effective [20], but why a small proportion of BCTs had been included in the interventions in this review is not clear. Although interventions were generally well reported, older studies, conducted prior to the recognition for the need for more consistent reporting of intervention contents, often lacked clarity in describing intervention components [22, 35, 65]. It is, therefore, possible that interpreting the content and replicating interventions from older studies could be problematic and lead to fewer BCTs being identified than used in the original trial. Similar to previous reviews, this review also identified that theory integration in the intervention design process was relatively limited [20, 23, 24, 66], which could also explain why more than half of the interventions were not effective [42, 43, 46, 48, 50].

It has been suggested that lifestyle interventions to prevent women continuing to engage in harmful health behaviors while pregnant often fail as there appears to be unique barriers to behavior change during pregnancy [67]. Although pregnancy is a very motivating time to change unhealthy behaviors [12], it is a brief period and so the opportunity for new habit formation, which is generally believed to take around 66 days (range 18–254 days), is limited [67, 68]. Furthermore, there are also competing lifestyle factors that can influence successful behavior change in pregnancy, such as social circumstances, relationship issues, financial restraints, and the priority to change the desired behavior change during this significant life period [67]. It is also possible that women are unaware of what type of behavior change is recommended in pregnancy; qualitative work on alcohol advice in pregnancy highlighted that although women had received advice on alcohol consumption, few had been informed of the official guidelines [69]. In line with this, and to prevent unnecessary harm, the WHO recommend that health care professionals ask pregnant women about alcohol and drug use at the earliest opportunity, offer a brief intervention to those who are using these substances, and refer them to more specialized services if required [70].

Alcohol consumption during pregnancy has been shown to be highest among women over 35 years and increases in association with higher incomes and increasing years of education [71]. This was reflected in four of the included alcohol studies [42, 43, 45, 49], two of which were effective in reducing alcohol consumption [45, 49]. As good intervention outcomes can be attributed to higher levels of education, higher household income, and social stability [43], this may partially explain why the interventions in these two trials were effective. When making assumptions based on this, however, it is noteworthy that these two trials [45, 49] reported incorporating theory and gave further support in addition to the one-off delivery of the intervention, which the non-effective trials [42, 43, 46, 48, 50] had not done.

Although data were not formally extracted from the illicit drug trials, an observation made during the screening phase was that in four of the trials, participants were required to be residential for all or part of the intervention delivery period [55–58]. This is an important contextual factor to consider for the illicit drugs use interventions as having to reside in the treatment facility, during some or all of intervention delivery period, has been shown to have a negative impact on intervention effectiveness regardless of how useful the components of the interventions may be [57]. It is therefore possible that the effectiveness of the interventions was more influenced by contextual factors than BCT content; however, more work would be required before any conclusions could be drawn around this assumption.

Of the 16 categories of BCTs in the BCTTv1 [35], some were not evident in any of the interventions for alcohol consumption reduction. Although there will be BCTs that are not appropriate or relevant to reducing harmful substance use among pregnant women, there is evidence to show that there are particular categories of BCTs that may be effective for this target group, but were not used in any of the included interventions [72–77]. “Identity” was one such category, despite identity being a known strong motivator for change. For example, in both alcohol consumption and illicit drugs use, adopting the role of “provider for the baby” has been associated with positive changes in behavior [72]. “Self-belief” was another category from which no BCTs were included but may be useful. Findings from several countries [73–75] have shown a strong positive relationship between self-efficacy, the belief in the self’s ability to achieve set goals [76], and being able to successfully change unhealthy behaviors during pregnancy. This has also been found in smoking in pregnancy, where higher levels of self-belief in abilities have been found to be a strong predictor of smoking cessation during pregnancy [73, 77]. On the basis of such findings, it has been recommended that

interventions incorporate components aimed to boost women's self-efficacy and beliefs in their ability [73, 77].

## Conclusion

There is evidence to show some BCTs, including: action planning, behavioral contract, prompts/cues, self-talk and offer/direct toward appropriate written materials, problem solving, feedback on behavior, social support (unspecified), information about health consequences, behavior substitution, assess current readiness and ability to reduce excessive alcohol consumption, goal setting (behavior), and tailor interactions appropriately, could be useful in achieving reduction in alcohol consumption during pregnancy. No BCTs were found to show effectiveness in achieving abstinence from illicit drug use. Only a small proportion of potential BCTs have been tested in the interventions reviewed, and few interventions had been informed by theory to any great extent. Recommendations for future work include incorporating theory throughout the entire intervention design process, exploring the potential effectiveness of a broader range of BCTs, and giving consideration to contextual factors that may affect the effectiveness of interventions.

## Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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## Compliance With Ethical Standards

**Authors' Statement of Conflict of Interest and Adherence to Ethical Standards** The authors declare that they have no conflict of interest.

**Authors' Contributions** Libby Fergie led the study and wrote the manuscript. Libby Fergie, Tom Coleman-Haynes and Katarzyna A. Campbell, performed the analysis. All authors had input to the study design and final edits to the manuscript.

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