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Mobile Telephone-Delivered Contingency Management interventions promoting behaviour change in individuals with substance use disorders: A meta-analysis

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Abstract

BACKGROUND/AIMS: Contingency management (CM) interventions have gained considerable interest due to their success in the treatment of addiction. However, their implementation can be resource intensive for clinical staff. Mobile telephone-based systems might offer a low-cost alternative. This approach could facilitate remote monitoring of behaviour and delivery of the reinforcer and minimise issues of staffing and resources. This systematic review and meta-analysis assessed the evidence for the effectiveness of mobile telephone delivered CM interventions to promote abstinence (from drugs, alcohol and tobacco), medication adherence and treatment engagement among individuals with substance use disorders.

DESIGN: A systematic search of databases (PsychINFO, CINAHL, MEDLINE PubMed, CENTRAL, Embase) for randomised controlled trials and within-subject design studies (1995-2019). The review was conducted in accordance with PRISMA statement. Protocol registered on PROSPERO.

SETTING: All included studies originated in the USA.

PARTICIPANTS: Seven studies were found, including 222 participants. Two targeted alcohol abstinence among frequent drinkers and four targeted smoking cessation (in homeless veterans and those with post-traumatic stress disorder). One targeted medication adherence.

MEASURES: The efficacy of CM to increase alcohol and nicotine abstinence was compared with control using several outcomes; Percentage of Negative Samples (PNS), Quit Rate (QR) and Longest Duration Abstinent (LDA) at the end of the intervention.

FINDINGS: The random effects meta-analyses produced pooled effect sizes of; PNS (d=0.94(95% CI:0.63-1.25)), LDA (d=1.08(95% CI:0.69-1.46)), and QR (d=0.46(95% CI:0.27-0.66)), demonstrating better outcomes across the CM conditions. Most of the studies were rated as of moderate quality. 'Failsafe N' computations for PNS indicated that 50 studies would be needed to produce a non-significant overall effect size. None could be calculated for QR and LDA due to insufficient number of studies.

CONCLUSION: Mobile telephone delivered contingency management performs significantly better than control conditions in reducing tobacco and alcohol use among adults not in treatment for substance use disorders.

KEY WORDS: mobile-telephone, remote monitoring, financial incentives, contingency management, substance use, drug use

Introduction

Contingency management (CM) interventions, based on the scientific principles of operant conditioning, involve the application of positive reinforcement (e.g. monetary incentives)contingent upon behaviour change.CM is among the most efficacious psychosocial interventions for substance use disorders and has gained considerable interest due to its success in encouraging health-related behaviour change, including treatment engagement and attendance, medication adherence and abstinence from substance use as evidenced in several recent meta-analyses (1-5).

Despite the evidence for CM interventions in the treatment of substance use, there are challenges and barriers impeding their implementation. To ensure maximum effectiveness, there are several key principles of operant conditioning that contingency management interventions must satisfy: objective verification that the treatment goal has been achieved, minimal delay in delivering the reinforcement and sufficient magnitude of the reinforcer to make it effective (3). Therefore, CM requires frequent monitoring of behaviour change and differential delivery of reinforcement making their implementation resource intensive and burdensome (6, 7) and creates challenges and barriers to their delivery. Given the widespread availability and use of mobile phones among the general public (94% of adults in the United States and 95% in the United Kingdom (8)), the use of mobile technologies is an expanding approach to enhance the reach of health care interventions. Mobile phone ownership among those affected by substance use disorders is lower, but comparable to the National average. With 83% of patients receiving drug treatment in the UK reporting to own a mobile phone (9), this might be a feasible platform upon which healthcare could be delivered in the treatment of substance use disorders (10). The remote delivery of CM interventions has been developed to enable greater accessibility to these interventions, allowing them to be delivered without the need for recurrent attendance at clinical services (11). Remote CM has been used to target substance use and other health related behaviours in individuals who might not normally access treatment services (12). This approach also enables services to maintain contact with patients over a longer period to support recovery and provide an early warning of relapse (13).

Development of these interventions can be guided by the basic scientific principles on which CM interventions are based, to ensure they remain effective while being feasible and acceptable to all. Mobile technology has been used to accomplish one or both of the following key principles of contingency management; (a) monitor the target behaviour, or (b) deliver incentives for satisfying the target behaviour contingency (14). Using mobile technology to monitor the target behaviour remotely is typically achieved by wireless submission of data. For example, a number of studies targeting alcohol intake require participants to continuously wear a Secure Remote Alcohol Monitoring (SCRAM) bracelet, which works by detecting metabolites of alcohol excreted through sweat (15-17). Data is available to researchers and provides a continuous overview of alcohol consumption. Studies promoting smoking cessation typically require participants to submit videos via a web camera of themselves taking a breath carbon monoxide test with the results (18-20). Medication adherence is typically monitored using electronic or medication event monitoring systems (MEMS) caps; micro-circuitry fitted to pill bottles or containers that issue a time stamp upon opening and closing (21-24).

Technology has been incorporated into CM interventions to remotely deliver incentives (18-20, 25-34). Typically, participants receive messages about their 'earnings' (monetary value accrued of reinforcer), which are generated automatically and sent shortly after the participant engages in the target behaviour (35). The emergence of study pre-paid debit cards (an automated reward payment platform) allows financial incentives to be electronically loaded onto the participant's card once satisfaction of the target behaviour has been verified. Although these cards are linked to the study, they mimic that of a debit/credit card, allowing for the withdrawal of cash as ATMs and electronic purchases. Immediate delivery of the reinforcement is key to the principles of CM and has been consistently shown to be a significant moderator of effect size: responsible for generating an effect size almost twice that of studies using more delayed delivery (3). Additionally, inconsistent delivery of the reinforcement may result in insufficient exposure to the incentives, and hinder the development of a clear contingent relationship between behaviour and the incentive (36). Technology makes it easier to deliver the reinforcer consistently and on every presentation of the target behaviour.

Given these advantages and the increasing use of mobile technologies, there is growing interest in utilising mobile phones to deliver CM. This is the first systematic review and meta-analysis assessing the evidence specially for the effectiveness of mobile telephone delivered contingency management interventions to promote behaviours to encourage abstinence (from drugs, alcohol and tobacco), medication adherence and treatment engagement among individuals with substance use disorders.

Methods

We conducted a systematic review and meta-analysis of randomised controlled trials and within subject designs to examine the effectiveness of mobile telephone based contingency management interventions for the treatment of substance use disorders. A protocol for the current review is available on PROSPERO (Registration number: CRD42018093598; please see Appendix A for a copy of the published protocol).

Search Strategy

The review was carried out in accordance with The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (37). Studies were identified using a keyword search of the following online databases: PsychINFO, CINAHL, MEDLINE PubMed, CENTRAL in the Cochrane Library and Embase using the following search terms: "contingency management" OR contingen* reinforcement OR voucher OR reinforcement OR reward OR incentive OR economics OR payment OR prize OR monetary OR money OR financial OR gift card OR lottery OR loyalty card **AND** substance-related disorder OR drug dependence OR drug misuse OR drug abuse OR alcoholism OR alcohol abuse OR drug dependence OR addiction OR substance abuse OR substance misuse OR smoking OR nicotine OR opioid OR narcotic **AND** treatment outcome OR drug dependence treatment OR adher* OR compliance OR rehabilitation OR engage OR abstinen* OR cessation OR behavio$r change OR therapy OR effective OR reduction OR attend **AND** text messaging OR telephone OR mobile OR phone OR remote monitoring. All databases were searched for studies published between 1995 and December 2018.

Studies

Randomised controlled trials (RCTs) that compared telephone delivered Contingency Management interventions with other treatment interventions such as Motivational Enhancement Therapy, Cognitive Behaviour Therapy, or treatment as usual, were included. Within subject designs comparing no intervention/ baseline with an intervention phase were also included as these designs are relatively common in the field of behaviour analysis.

Intervention(s)/Exposure(s)

We only included studies that used mobile telephones to monitor behaviour and/or deliver incentives remotely and targeted behaviours to encourage abstinence (from drugs, alcohol and tobacco), medication adherence and treatment engagement. Typically, reinforcement interventions include a number of components (e.g., financial incentives plus praise or feedback about progress), with the

independent influence on treatment efficacy not always measured. Therefore, we did not require that studies isolated the effects of incentives from those common elements for inclusion. For studies that employed a between-subject design, the comparator was the control group who received: no contingency management; treatment as usual; alternative comparable interventions; or face to face contingency management. For those studies that employed a within-subjects design, the comparison could be a no intervention baseline phase that preceded and followed the intervention, or a multiple-baseline design wherein the timing of the incentive intervention was staggered in time across different targets or different participants.

Primary Outcomes

The efficacy of telephone delivered contingency management was assessed using the following outcomes;

1. Abstinence, as measured by: proportion of individuals who are continuously abstinent; length of abstinence period; percentage days abstinent (PDA)
2. Medication Adherence, as measured by: proportion of individuals who are taking their medication as prescribed
3. Treatment Engagement, as measured by; percentage of days in attendance or engagement in therapeutic activities

Data extraction and synthesis

Endnote X8 was used to manage records throughout this review, and Microsoft Excel was used for data extraction. All records were extracted, and duplicates removed by a single reviewer (CG) using an extraction table created specifically for the review. Two review authors (CG, AM) independently scanned the title and abstract of every record retrieved to determine which studies should be further evaluated for inclusion. Three response options ('yes', 'no', and 'maybe') were used for excluding records or promoting them to the next stage of the winnowing process. All potentially relevant articles were investigated as full text and any uncertainties were discussed between the review authors. This process is detailed in a PRISMA flow chart (Figure 1). Authors of 3 studies (32, 38, 39) were contacted to obtain additional study data. Where not explicit in manuscripts, authors were also asked to clarify how missing samples were handled in the analyses (analysed as positive or omitted).

Outcome measures

Standardised means differences were calculated for each individual study using Percentage negative samples (PNS) or Longest Duration Abstinent (LDA). Odds ratios were calculated for Quit rates (QR).

Quality Assessment

The 'Quality Assessment Tool for Quantitative Studies' (40) was used to assess the quality of included studies at outcome level. This tool assesses the internal and external validity of each study and rates the quality across six dimensions (selection bias, study design, confounds, blinding, data collection and withdrawals/ dropouts). Studies are rated as being of a Strong, Moderate or Weak quality based on these individual domains.

Risk of bias assessment

Due to studies reporting positive results being more likely to be published in the literature, resulting in an over representation of positive effects (41), publication bias was assessed using the 'failsafe N' technique (42). Comprehensive Meta-Analysis software V3 (43) was used to calculate the number of studies averaging a Z-value of zero that would be needed to result in a non-significant overall pooled effect size.

Data Analysis

Meta-analyses were carried out using Cochrane Collaboration Review Manager software (RevMan v5.3). To calculate effect size for treatment evaluation studies, standardised mean difference is the most common method. Risk difference Odds Ratio was used for Quit Rate outcome. An effect size favouring the treatment group and showing more success than the comparison group is illustrated by a positive sign. Consistent with standard practice in weighting effect size, we entered all data into a generic inverse variance analysis (Lipsey & Wilson). All meta-analyses were conducted as random effects analyses due to the variety of target behaviours, populations and CM interventions used. The efficacy of CM was compared with control using a number of outcomes: Percentage of negative samples (PNS), Quit rate (QR) and Longest Duration Abstinent (LDA). Despite studies reporting data on other types of outcomes (e.g. money spent on alcohol/drugs), we only included those of greatest relevance to assessing the effectiveness of CM.

Results

Included Studies

A total of 1404 records were identified. Following removal of duplicates, 734 records remained and were screened at title and abstract level. Following the removal of 687 ineligible records, 47 records were screened at full-text level. A total of 7 studies met the inclusion criteria (see PRISMA flow diagram, Figure 1) and were included in the review (22, 32, 36, 38, 39, 44, 45) .

INSERT FIGURE 1

Study targets and population

Intervention target behaviours varied across the 7 studies. Six studies used mobile telephone delivered CM to target abstinence. More specifically, two targeted alcohol abstinence among frequent drinkers (36, 38) and four targeted smoking cessation in smokers (including homeless veterans and those with PTSD) (32, 39, 44, 45). One study targeted medication adherence among individuals with HIV and substance misuse (22). No studies targeted treatment engagement (attendance or engagement in therapeutic activities). The populations targeted were adults not in treatment for substance use disorder. See Table 1 for a full description of included studies.

INSERT TABLE 1

Technologies used in monitoring and delivering reinforcement

Included in this review are studies that used mobile telephones to monitor behaviour and/or deliver the reinforcement remotely and targeted behaviours to encourage abstinence (from drugs, alcohol and tobacco), medication adherence and treatment engagement. Six studies used mobile telephones to monitor behaviour. The most common method involved participants taking videos of themselves completing a breath carbon monoxide (CO) test and presenting the results as proof of achieving the target behaviour. These videos were remotely submitted to the researchers before reinforcers were delivered. One study targeting adherence to anti-retroviral medications in individuals living with HIV and substance misuse problems, used electronic pill dispensers to transmit a message to a software program for analysis and interpretation each time the device was opened (22).

In 5 of the included studies mobile telephones were also used to deliver the reinforcement. More specifically, messages of verbal praise were commonly used to confirm achievement of the target behaviour and to indicate earnings (22, 32, 36, 38, 45). Remote monitoring of behaviour allows for prompt verification of goal satisfaction. While the majority of the studies mailed earnings to participants in cheque form, two studies employed the use of reloadable credit cards to deliver the reinforcer immediately following verification of the target behaviour (22, 38).

Reinforcement type & schedules

The type of reinforcement used varied across studies. Six studies used monetary incentives (22, 32, 36, 38, 39, 44); gift cards, cheques, or cash loaded onto a debit card, while one used prize-based reinforcement (45). Consistent with traditional face-to-face contingency management interventions, most of the studies included in this review employed differential reinforcement of other behaviour (DRO) to reinforce abstinence, whereby the reinforcement was delivered contingent on negative urine

and breath CO samples. An escalating schedule of reinforcement whereby the amount of reinforcement increased progressively following consecutive achievement of the target behaviour was employed by all studies.

Quality Assessment

To ascertain the internal and external validity as well as any biases and confounds of the included studies, two reviewers (CG and AM) worked independently to rate the quality of each study across six domains. Using the 'Quality Assessment Tool for Quantitative Studies' (40), each study was rated as being of Strong, Moderate or Weak across six dimensions (selection bias, study design, confounds, blinding, data collection and withdrawals/ dropouts). Ratings for all included studies are summarised in table 2. Overall, most of the retrieved studies had a high quality of data collection and reporting withdrawals/dropouts. None of the studies were double blinded as blinding both participants and providers to contingency management interventions is not possible due to the nature of the intervention. All studies employing a randomised controlled trial design included details regarding the method used to randomise participants. Studies employing a within-subjects design were rated as being of moderate quality as per guidelines from the EPHPP quality assessment tool (40).

Publication bias

Publication bias was assessed using the 'failsafe N' technique (42). For PNS, 50 studies would be needed to result in a non-significant overall pooled effect size. For QR and LDA, 'failsafe N' could not be calculated due to and insufficient number of studies.

INSERT TABLE 2

Meta-Analyses

The efficacy of CM to encourage abstinence was compared with control using a number of outcomes; Percentage of negative samples (PNS), Quit rate (QR) and Longest Duration Abstinent (LDA). Due to only one study targeting medication adherence, data for this outcome could not be collated. Therefore, data across six studies was used for the meta-analyses.

The meta-analysis for PNS combined results across 5 studies (191 participants) assigned to 5 CM conditions and 5 non-CM conditions (non-CM condition details are provided in table 1). The random effects meta-analysis produced a pooled effect size of d=0.94 (95% CI:0.63-1.25), with CM performing

better than the non-CM condition (Fig.2). Variability of effects between studies was not due to between-study heterogeneity (I^2 = 6%).

INSERT FIGURE 2

For QR, 2 studies (62 participants) assigned to 2 CM conditions and 2 non-CM conditions were included. The random effects meta-analysis produced a pooled effect size of d=0.46 (95% CI:0.27-0.66), with CM performing better than the non-CM condition (Fig.3). Variability of effects between studies was not due to between-study heterogeneity (I^2 = 0%).

INSERT FIGURE 3

The meta-analysis for LDA combined results across 2 studies (119 participants) assigned to 2 CM conditions and 2 non-CM conditions. The random effects meta-analysis produced a pooled effect size of d=1.08 (95% CI:0.69-1.46), with CM performing better than the non-CM condition (Fig.4). Variability of effects between studies was not due to between-study heterogeneity (I^2 = 0%).

INSERT FIGURE 4

Discussion

In this systematic review and meta-analysis, we examined the efficacy of mobile telephone delivered contingency management for enhancing treatment of substance use disorders. The random effects analyses showed that mobile telephone delivered CM performed significantly better than control conditions (involving no reinforcement contingent on behaviour change) in reducing tobacco and alcohol use among adults not in treatment for substance use disorders across the three outcomes of interest; Percentage of negative samples (PNS), Quit rate (QR) and Longest Duration Abstinent (LDA) with pooled effect sizes of d=0.94 (95% CI:0.63-1.25); d=0.46 (95% CI:0.27-0.66) and d=1.08 (95% CI:0.69-1.46) respectively. Only one study has targeted medication adherence among individuals with HIV and substance misuse (22) and no studies have targeted treatment engagement (attendance or engagement in therapeutic activities). This review is the first to directly assess the evidence for the effectiveness of CM delivered using mobile telephones. The results across the three outcomes assessed in this review are of major clinical importance, however they must be treated with caution due to small number of studies with multiple outcomes.

The use of technology to monitor behaviour and deliver reinforcement has been well developed over the last decade and continues to offer an effective and practical means to target treatment related behaviours over longer periods of time and enable comprehensive outcome data to be collected on a continuous and ongoing basis. An existing systematic review (14) of controlled studies published between 2004 and 2015 provides support for the efficacy of technology based (e.g. internet, computer, mobile telephone) reinforcement interventions remotely implemented to target health behaviours, including substance use. However, the review was inclusive of all technology-based CM including less remote applications using computers and landline telephones. Also, a meta-analysis was not undertaken by these authors and therefore no statistical comparisons and conclusions were provided. Nonetheless, considering the growing contribution of technology-based interventions in the treatment of addiction, providing an up-to-date review of the literature is important. This is emphasised in this review, as almost 50% of included studies in the meta-analysis have been published since the last review in 2015.

This review only included interventions delivered by mobile telephones, a strategy which led to almost 50% of articles screened for eligibility excluded as they employed remote delivery by another means, most commonly by computer. Therefore, a small number of studies were included. Although our results should be interpreted with caution due to this, the effect across all studies is consistent and substantial, and allows us to draw preliminary conclusions regarding the potential effectiveness of mobile CM interventions. Furthermore, one might also argue that combining studies of different designs is a study limitation. However, all studies in each comparison employed the use of mobile telephones to address the same clinical outcome among a substance use population group. In addition to this, all studies had relatively consistent parameters of the contingency management interventions (i.e. escalating reinforcement schedules) to strengthen behaviour change, making it appropriate to combine them. A key distinction was not the design of the studies, but rather the extent to which they were able to yield an unbiased estimate of the effect size in question (46).

Overall, most of the identified studies demonstrated a high quality of data collection methods by employing standard assessment tools of known reliability and validity and explicitly reported numbers and reasons for withdrawals and dropouts. Nonetheless, none of the studies were double blinded as blinding both participants and providers to contingency management interventions is not possible due to the nature of the treatment. Regarding informativeness of included studies, all employing a randomised controlled trial design included details regarding the method used to randomise participants. Studies employing a within-subjects design were rated as moderate quality as per

guidelines from the EPHPP quality assessment tool (40). In addition, analyses of missed samples at an outcome level varied across studies. Although not always explicitly stated in study reports, missed samples could be treated as positive or simply omitted from analyses. Adherence to study procedures (i.e. providing daily CO and BrAC samples) was lower in control conditions across two studies (36, 44) resulting in less samples being obtained in these group. Therefore, coding missed tests as positive might have differentially deflated abstinence rates in the monitoring condition and inflated differences between conditions in these studies. In such cases, analysing the proportion of negative CO and BrAC tests outcome with the number of tests submitted in the denominator and missed tests omitted might have yielded more accurate results.

Despite these limitations, several study level strengths are also worth noting, such as retention rate across studies. In addition to this, comparison group conditions differed among studies, with some control participants being yoked to a participant in the contingency management condition and receiving a payment equal to their paired participant (38, 39). This strategy ensures that participants across both conditions receive the same payment schedule with the same likelihood of escalations, resets and bonuses. This isolates the effects of the contingency for comparison across groups. Another strength of the studies included in this review was the inclusion of biological indicators (objective measures) to verify substance use rather than relying on self-report. This is key in ensuring the reinforcer is only delivered upon the participant satisfying the target behaviour and outcome data is reflective of goal directed behaviour. Regarding the review, there are also several notable strengths worth noting. This is the first systematic review and meta-analysis assessing the evidence specially for the effectiveness of mobile telephone delivered contingency management interventions to promote treatment in individuals with substance use disorders. Synthesising data across the existing studies allows us to identify which outcome measures and population groups are most likely to benefit from the intervention. The last decade has seen an emergence in studies assessing the initial efficacy and feasibility of mobile telephone delivered CM interventions to promote smoking cessation and alcohol abstinence. In the near future, we suspect, the body of literature demonstrating the effectiveness of these interventions will flourish.

Furthermore, the studies in this review included relatively short interventions (on average 4-5 weeks) and small sample sizes (as illustrated in table 1). Future research should assess the long-term benefits of providing extended mobile delivered CM interventions and use larger sample sizes to enable definitive conclusions to be made about clinical outcomes. Long-term incentive programmes, as developed by Silverman and colleagues in the Therapeutic Workplace (47), have been shown to

demonstrate sustained treatment effects among those with substance use disorders and may offer a cost-effective means to encourage drug abstinence and treatment adherence over a much longer period.

It is also worth noting that no studies compared differences in treatment effects between in-person delivered CM and mobile delivered CM interventions. Our findings are broadly consistent with those found for face to face delivered CM targeted at smoking and alcohol cessation as evidenced in previous meta-analyses (smoking cessation (d=0.31) (2) and alcohol cessation (d= 0.32)) (3). The limitations discussed and the lack of evidence available does however present avenues for future research. Although mobile telephone delivered CM might appear to be an efficacious treatment for alcohol abstinence and smoking cessation, there are no current studies evaluating its impact in reducing drug use behaviours. Technological developments will ultimately enable advances to be made in generating effective and accurate monitoring equipment to enable us to target substance misuse behaviours successfully. This is important as the remote delivery of these interventions has the potential to expand the reach and landscape of treatment delivery among individuals not in contact or receiving treatment within drug services. Mobile telephones might offer a more accessible and convenient means of delivering CM interventions to those less accessible individuals at a potentially critical time in their treatment journey (12).

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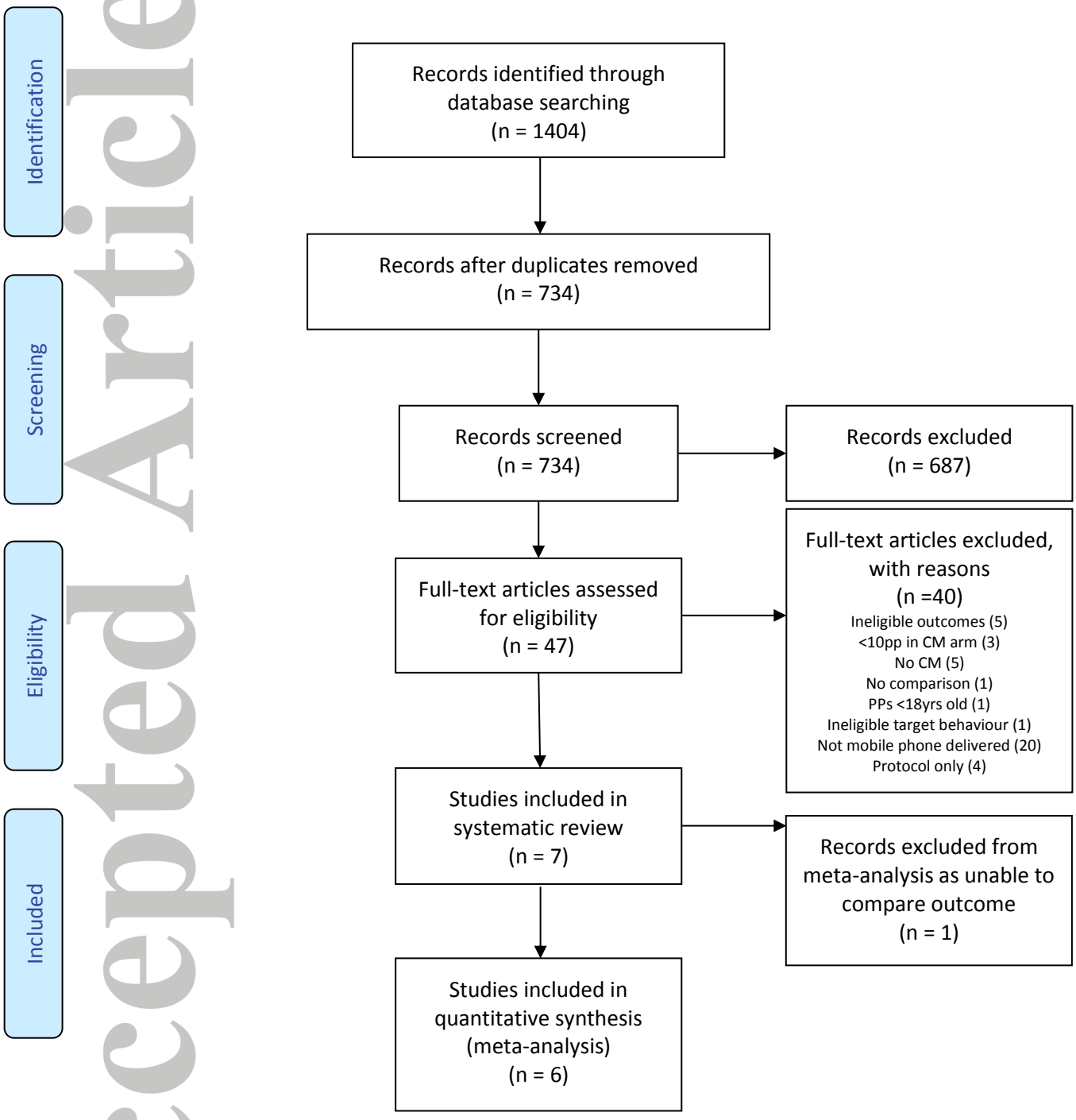
Figure 1 PRISMA flow diagram



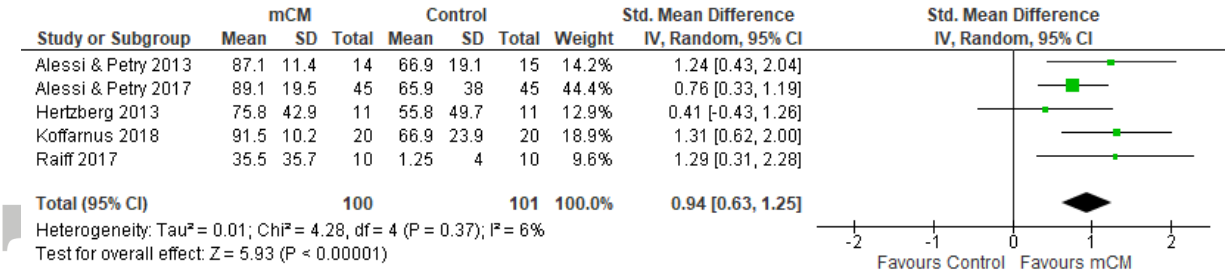


Figure 2 Forest plot for Percentage Negative Samples by end of treatment for all substances.

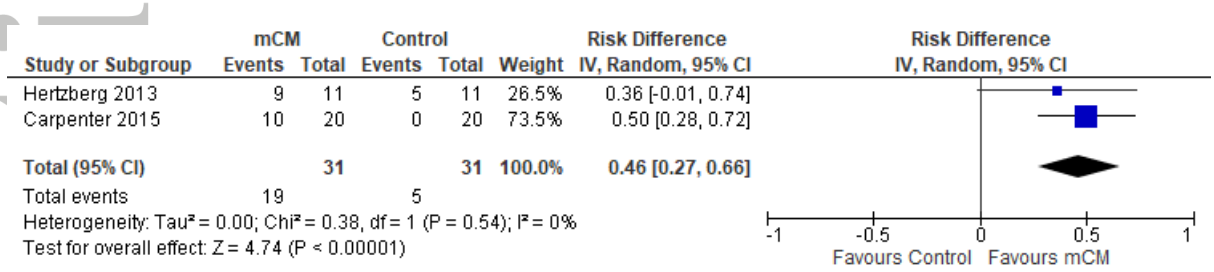


Figure 3 Forest plot for Quit Rate by end of treatment for nicotine.

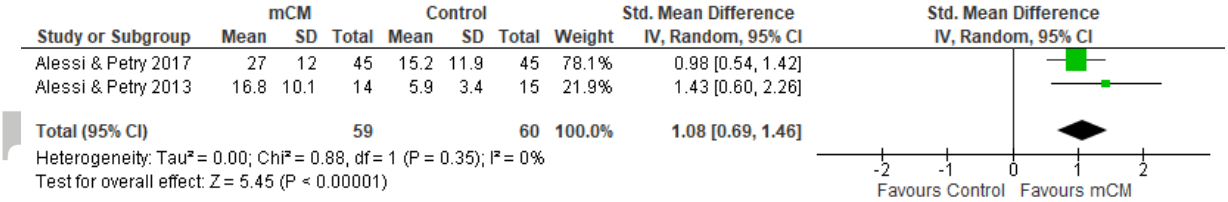


Figure 4 Forest plot for Longest Duration Abstinent for all substances.

Study author (year)	*Design*	*Sample size (Baseline)*	*Retention (end of intervention)*	*Number of Conditions*	*Longest follow-up (months)*	*Treatment duration*	*Target behaviour*	*Intervention procedure*	*Type of reinforcement*	*Reinforcement schedule*	*Reward delivery*	*Type of mobile used*	*Use of telephone*	Primary Outcomes	
														CM condition Mean (SD)	*Control condition Mean (SD)*
Alessi et al. (2013)	RCT	30	100%	2 (BrAC monitoring only or BrAC monitoring plus CM)	None	4 weeks	Alcohol abstinence	1-3 daily prompts for BrAC readings. Incentives earned for alcohol-negative tests (<0.02 g/dl % BrAC).	Monetary	Escalating with reset	Gift card or cheque.	Study cell phone with video camera & breathalyser	Monitor behaviour & deliver reinforcer	PNS 87.1% (11.4). LDA 16.8 (10.1)	PNS 66.9% (19.1). LDA 5.9 (3.4)
Alessi et al. (2017)	RCT	90	100%	2 (mHealth monitoring only or mHealth monitoring + reinforcement)	6	4 weeks	Smoking cessation	1–3 daily prompts for CO tests. Prize draws for smoking-negative on-time CO tests (CO ≤ 6 ppm).	Prize draw	Escalating draws with reset	Prize draws redeemable weekly.	Study cell phone with video camera & CO monitor	Monitor behaviour & deliver reinforcer	PNS 89.1% (19.5%). LDA 27.0 (12.0).	PNS 65.9% (38.0%). LDA 15.2 (11.9).
Carpenter et al. (2015)	WS	20	100%	N/A	6	4 weeks	Smoking cessation	2 daily prompts for CO tests. Incentives earned for smoking-negative CO tests	Monetary	Escalating with reset	Mailed cheque	Study cell phone with video camera & CO monitor	Monitor behaviour & deliver reinforcer	Quit rate at four weeks 50% (n=20)	

								(CO ≤ 6 ppm).						
Hertzberg et al. (2013)	RCT	22	91%	2 (mCM or yoked mCM/ non-contingent)	3	4 weeks	Smoking cessation	2 daily prompts for CO tests. Incentives earned or smoking-negative CO tests (CO ≤ 8 ppm).	Monetary	Escalating with reset	Mailed cheque	Study cell phone with video camera & CO monitor	Monitor behaviour	QR at 4 weeks 82% (n = 9 of 11). PNS 75.8% (42.9%)	QR at 4 weeks 45% (n = 5 of 11). PNS 55.8% (49.7%)
Moore et al. (2015)	WS	10	100%	N/A	None	12 weeks	Medication adherence	Centralized Off-site Adhe Rence Enhancement (CARE) program. Adherence was measured by electronic pill dispenser	Monetary	Escalating for weeks 1–6 of treatment, followed by tapering, variable interval reinforcement for week 7–12.	Debit card	Participant's own cell phone	Deliver reinforcer	PDA. Medication adherence improved from 80.7% at the start of treatment to 93.2% at the end of treatment.	
Raiff et al. (2017)	WS (nonconcurrent multiple-baseline design)	10	100%	N/A	1	14 days	Smoking cessation	Group CM procedure. 2 daily CO tests. Incentives earned for smoking negative CO tests (CO ≤ 4 ppm)	Monetary	Escalating with reset	Mailed gift card	Participant's own smartphone	Monitor behaviour	PNS at baseline (M= 1.25%, SD = 4.0) and treatment (M= 35.5%, SD = 35.7).	

								plus bonus when both members of the pair met their target.							
Koffarnus et al. (2018)	RCT	40	100%	2 (mCM or yoked mCM/ non-contingent)	1	21 days	Alcohol abstinence	Thrice daily prompts for BrAC readings Incentives earned for alcohol-negative tests (<0.02 g/dl % BrAC).	Monetary	Escalating with reset	Debit card	Participant's own cell phone	Monitor behaviour & deliver reinforcer	PDA 85%. PNS 91.5% (10.2%).	PDA 38%. PNS 66.9% (23.9%).

Table 1. Description of each included study and intervention.
Abbreviations – **RCT**: Randomised Clinical Trial, **WS**: Within-subjects, **BrAC**: Breath Alcohol Concentration, **CM**: Contingency Management, **PNS**: Percentage of Negative Samples, **LDA**: Longest Duration Abstinent, **PDA**: Percentage of Days Abstinent **IVR**: Interactive Voice Response **QR:** Quit rate

Table 2 EPHPP ratings for al included studies.

Study	Selection Bias	Study Design	Confounds	Blinding	Data Collection	Withdrawals/Dropouts	Overall
Aharonovich (2017)	2	1	1	2	1	1	**Strong**
Alessi (2013)	2	1	2	3	1	1	**Moderate**
Alessi (2013)	2	1	1	3	1	1	**Moderate**
Carpenter (2015)	3	2	1	3	1	1	**Weak**
Hertzberg (2015)	3	1	1	3	1	1	**Weak**
Moore (2015)	2	2	1	3	1	1	**Moderate**
Raiff (2017)	2	2	1	3	1	1	**Moderate**
Koffarnus (2018)	2	1	1	3	1	1	**Moderate**

1 = Strong, 2 = Moderate, 3 = Weak