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To cite this article: Julie C. Gass , Jennifer S. Funderburk , Robyn Shepardson , Jesse D. Kosiba , Lauren Rodriguez & Stephen A. Maisto (2021): The use and impact of self-monitoring on substance use outcomes: A descriptive systematic review, Substance Abuse, DOI: [10.1080/08897077.2021.1874595](https://doi.org/10.1080/08897077.2021.1874595)

To link to this article: <https://doi.org/10.1080/08897077.2021.1874595>



Published online: 22 Feb 2021.



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The use and impact of self-monitoring on substance use outcomes: A descriptive systematic review

Julie C. Gass, PhD^{a,b}, Jennifer S. Funderburk, PhD^{c,d,e}, Robyn Shepardson, PhD^{c,e}, Jesse D. Kosiba, MS^{c,e}, Lauren Rodriguez, MA^{a,b}, and Stephen A. Maisto, PhD^{c,d}

^aVA Center for Integrated Healthcare, Western New York VA Healthcare System, Buffalo, NY, USA; ^bDepartment of Psychology, University at Buffalo, State University of New York, Buffalo, NY, USA; ^cVA Center for Integrated Healthcare, Syracuse VA Medical Center, Syracuse, NY, USA; ^dDepartment of Psychology, Syracuse University, Syracuse, NY, USA; ^eDepartment of Psychiatry, University of Rochester, Rochester, NY, USA

ABSTRACT

Background: Self-Monitoring (SM), the act of observing ones' own behavior, has been used in substance use treatment because SM may bring conscious awareness to automatized substance use behaviors. Empirical findings regarding SM's effectiveness are mixed. The aim of this study was to synthesize the literature for the efficacy of SM on substance use. **Method:** A literature search was conducted using MEDLINE/PubMed. **Results:** Out of 2,659 citations, 41 studies with 126 analyses were included. Among analyses from studies rated Moderate ($n = 24$) or Strong ($n = 3$) quality, SM was shown to have a helpful effect (e.g., reducing substance use) 29% of the time; to have no effect 63.0% of the time; and to be detrimental in 8.0% of analyses. SM's helpful effects were associated with methodological characteristics including longer monitoring and Phone/IVR and EMA/Computer methodologies compared to Paper/Pencil. SM was more helpful in non-treatment-seekers (35.0% of analyses showed SM to be helpful compared to 25.0% of analyses with treatment-seekers). **Conclusions:** Results of this study suggest that SM, under certain circumstances, as the potential to be a low-cost, low-risk research and early intervention strategy for substance users.

KEYWORDS

Self-monitoring; assessment effects; systematic review; low-intensity intervention

Introduction

There are a wealth of efficacious, medium to high-intensity, change-based substance use treatments available to patients who use and have problems associated with substances.¹⁻³ These treatments, such as cognitive-behavioral therapy and medication, are not always feasible for patients, and successful behavior change during treatment may be affected by various factors, including fluctuations in motivation⁴, withdrawal symptoms⁵, and patients being in challenging contextual situations⁶. Individuals who overuse substances and individuals with substance use disorders (SUDs) are often ambivalent or unmotivated to change their behavior, which would tend to be detrimental to behavior change attempts.⁷

Interventions that focus on pre-change processes such as increasing awareness of substance use, and understanding precipitants to use, have been shown to be effective early in the behavior change process.⁸ An example is *self-monitoring*.⁹⁻¹¹ Self-monitoring (SM) is the simple act of documenting (e.g., in a diary) substance use and related variables (e.g., craving, situation, moods). SM has been included as an adjunctive component of most treatments (e.g., cognitive behavioral therapy inherently includes assessment of consumption and

related cognitions/situations¹²) and has been utilized as an early stand-alone intervention.¹³

SM has been defined in different ways,^{14,15} yet a core feature is the act of self-observation of aspects of the target behavior. It may be as simple as monitoring the outcome of interest (e.g., number of cigarettes smoked per day), or can be more complex (e.g., identifying smoking precipitants and contexts). The modality of monitoring also can vary, with options including retrospective recall, daily paper diary, and electronic methods such as cellular phones or apps.¹⁶⁻¹⁸ SM was initially introduced as a methodological concern in treatment studies, as it appeared that measurement reactivity was affecting treatment outcomes.¹⁴⁻²¹ Patients often report that self-monitoring helped them to reduce use and gain important insight into their behavior.²² Substance use studies have examined *assessment as an intervention* (e.g., using assessments to promote behavior change) for this reason—however, results are mixed across the literature as to whether SM interventions produce consistent outcomes for substance users.²²⁻²⁵ This history suggests that SM has the potential to have helpful therapeutic effects, but further research is needed to better understand its effects.

SM interventions have been tied to positive outcomes, including reduced weight in overweight/obese individuals, increased physical activity, improved adherence to medication regimens, and increased diabetic self-management.^{26–30} Given the similar cognitive and behavioral processes that underlie health behavior change and substance use behavior change, it would follow that substance users could similarly benefit. Theories explaining the proposed association of SM with improvements in health behavior and substance outcomes often have a theme of SM bringing the substance use, and its consequences, into greater attention. Specifically, Karoly and Kanfer¹⁵ theorized that the combination of greater attention to a behavior and explicit awareness of consequences of a behavior leads to decreasing frequency of the behavior. Rachlin³¹ expanded this by positing that monitoring a behavior causes an individual to think more about the consequences of the behavior. Related, Tiffany's³² dual process cognitive model posits that a great deal of substance use is done automatically without significant conscious thought.³² This theory suggests that unconscious addictive behaviors (e.g., reaching for a cigarette while driving) and cognitive processes (e.g., craving) prove extremely difficult to extinguish and treatments designed to increase conscious awareness could cause the behavior to be more extinguishable.³²

SM for substance use was a popular topic of research in the 1970s and 1980s, but mixed results diminished enthusiasm. In 1998, Leigh et al.³³ completed a literature review examining the impact of SM on alcohol use interventions and concluded that it can improve the outcome of other interventions, but was often not effective as a stand-alone treatment. More recently, there has been a revival in SM research, as investigators can now evaluate moment-to-moment SM and its outcomes using ecological momentary assessment (EMA). EMA methods utilize technology (e.g., smartphones, apps) to assess participants on a variety of measures at both fixed and random intervals in their real environments.

Consistent with SM theories, there are potential moderators of SM's effectiveness. Specifically, consistent with Rachlin³¹ and Karoly and Kanfer's¹⁵ theories, SM functions by bringing substance use behaviors into awareness; thus, methodological differences including variability in assessment strategy (e.g., EMA, paper-and-pencil measures in the lab or clinic) and the length/type/intensity of monitoring (e.g., multiple assessments per day via prompts versus infrequent assessments) may contribute to mixed results.^{17,34} Additionally, whether participants were compensated for engaging in SM may play a role. There is evidence that intrinsically motivated behavior leads to longer sustained change than behavior that is extrinsically (e.g., by being paid) motivating.³⁵ Finally, it is likely that participants who are more adherent to SM (i.e., complete more assessments) would see greater benefits of SM, as they are essentially more adherent to the treatment.

Characteristics of the sample may influence the relationship between SM and substance use. For example, whether the population is seeking treatment could change how SM

affects behavior. Research indicates that cognitive and behavioral processes often differ between treatment-seeking and non-treatment-seeking substance users,³⁶ and therefore SM may affect these groups differently. Additionally, it is worth considering what outcome is purported to be influenced by SM—studies have examined lapse/relapse as part of a quit attempt,³⁷ ad-lib consumption,²⁵ and non-consumption measures (e.g., self-reported craving³⁸), along with whether participants receiving SM are also receiving other treatments.

This systematic review focuses on examining the effect of extended SM (i.e., greater than one assessment) among substance users on changes to consumptive behaviors and changes in non-consumption processes (e.g., craving, affect, motivation to change). We extend upon previous research (e.g., Leigh et al.³³) by including studies with multiple substance use outcomes and more recent research. The aim of this review was to synthesize and describe the literature examining the impact of SM on a variety of substance use-related outcomes to determine the frequency with which studies have found SM to be helpful, detrimental, or to have no effect; and to review differences in the pattern of effects based on sample/study level differences.

Method

Literature searched

A primary literature search was conducted on May 9, 2018 using the MEDLINE/PubMed databases. A second search intended to update the article list was conducted on February 6, 2020. A third literature search that added more inclusive search terms was conducted on June 19, 2020. Studies published through December 2019 were considered for inclusion in this review.

Keywords

Searches included abstract keywords [(Assessment as intervention OR self-assessment intervention OR self-monitoring OR self monitoring OR self assessment OR self-assessment OR ecological momentary assessment reactivity OR EMA OR ecological momentary assessment OR assessment reactivity) AND (nic* OR smok* OR tobacco OR alcohol OR alco* OR drug OR substance OR illicit drug OR cocaine OR crack/cocaine OR heroin OR marijuana OR cannab* OR opi* OR methamphetamine OR halluc* OR barbiturate OR crack OR tranq* OR stimulant OR inhalant) NOT (cue reactivity)]. Secondly, reference sections of studies (a) included in this review, (b) and discussing SM and assessment reactivity theories were examined.

Eligibility

After studies were identified and duplicates removed, titles/abstracts were evaluated and several were eliminated based on the following criteria: (a) not in English; (b) a review/single-subject study; (c) not adult human subjects; (d) not

relevant to substance use. After this initial screen, full text articles were reviewed and eligibility was determined if the following criteria were met: (a) the sample consisted of current substance users at the time of the study; (b) extended self-monitoring in the natural environment (i.e., to be considered SM, it had to be more than a one-time assessment and could not occur only in the context of laboratory or clinic sessions) (c) at least one substance relevant outcome; (d) there was presence or description of an explicit evaluation of the relationship between self-monitoring and at least one substance outcome; (e) a study would not be eligible if all reporting was retrospective or cross-sectional (e.g., survey data). Regarding (d), this review was inclusive of several types of analyses, including (a) explicit comparison of groups who completed SM to groups who did not; (b) explicit comparison of groups who completed higher intensity SM to groups that completed lower intensity SM; and (c) within-subjects analysis examining how a substance use-related outcome changed from pre- to post-SM.

Study selection procedures

The initial literature search was conducted by two Masters-level research assistants. Additional literature was identified (by examining reference lists of relevant studies) by a Masters-level research assistant. After the initial searches were conducted, duplicates and irrelevant studies were eliminated. Abstracts of the remaining studies were examined by Masters-level research assistants, and irrelevant studies were eliminated. The first, fourth, and fifth authors and a research assistant reviewed full-text articles for inclusion. 20% of full-text articles were dually-rated, and we achieved a high level of agreement in this process (95%). Studies with questionable eligibility were reviewed by the first author, who made all final decisions in consultation/discussion with the entire study team, which occurred frequently throughout the course of this study period.

For studies determined to be eligible, the first, fourth, and fifth authors extracted several pieces of data from each article and analysis. All full text articles were dually extracted and we achieved high agreement on quantitative/countable items extracted (93%). Discrepancies were resolved by the first author reviewing the full text article and determining the correct data to be input. For each article, any analysis that was relevant to our study question was extracted, resulting in studies with more than one analysis included in this review. Each analysis was then coded as follows: Helpful (SM has a significant ($p < .05$) helpful, or positive, effect on the substance-relevant outcome), No Effect (SM had no significant effect on the outcome), or Detrimental (SM had a significant ($p < .05$) detrimental, or negative, effect on the outcome). Note that we extracted the cleanest analyses possible (e.g., if a study had an SM-only group, SM + treatment group, and non-SM group, we pulled analyses relevant to the SM-only vs. non-SM group to best show SM's effect), though many studies included other treatments in the SM and/or control groups. See Table 1 and its footnotes for details.

Quality assessment

Each eligible article was rated for quality using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies (QAT-Q).³⁹ THE QAT-Q is a validated quality assessment measure and was chosen because it can be flexibly applied to studies of different methodological design. Raters evaluated study design (Strong = Randomized Controlled Trial or controlled clinical trial; Moderate = cohort analytic, case-control, cohort [one group, pre-post], or interrupted time series; Weak = other or cannot tell), randomization/blinding (if randomization was used, to be Strong, studies needed to describe an appropriate method; in study designs with blinding: Strong = assessors and patients blind to condition; Moderate = assessors OR participants blind to condition; Weak = neither assessors nor participants blind to condition), confounds (Strong = no confounds OR 80–100% of confounds were statistically controlled; Moderate = 60–79% of confounds were statistically controlled; Weak = <60% of confounds were statistically controlled OR raters cannot tell if there were confounds), data collection methods (Strong = data collection tools/methods valid and reliable; Moderate = data collection tools/methods valid but not reliable; Weak = data collection tools/methods not valid or reliable, and attrition (Strong = attrition <20%; Moderate = attrition between 21% and 40%; Weak = attrition >40% or not reported). For the purposes of our review, studies were evaluated based on their evaluation of SM specifically and the quality with which the study examined SM. Therefore, we are not commenting on the quality of the study as a whole. This distinction generally only affected the study/statistical design domains. After each area was rated, a “final” score was applied using the cutoff suggested by authors of the instrument: Strong if there were no Weak ratings; Moderate if there was only one Weak rating, and Weak if there were two or more Weak ratings. All studies were dually-rated; the first author rated 100% of studies, and the fourth and fifth authors each rated 50% of studies. Agreement between the first and fourth/fifth authors was acceptable for the overall quality rating (71% agreement). For remaining disagreements, authors had a consensus meeting and resolved discrepancies.

Descriptive analyses

Systematic review was chosen in lieu of meta-analysis due to extreme methodological and statistical heterogeneity across the sample of studies. Results of this review are described primarily as proportions. Study characteristics were summed and converted to a percentage (i.e., out of the total number of studies) for presentation in the results. After an initial examination of results, we restricted investigation to studies that were rated as “strong” or “moderate” on the QAT-Q. We then examined how various study and analysis characteristics affected the proportion of analyses showing no, helpful, or detrimental effects.

For the results that describe how SM had an impact on outcome, results are presented not at the study level but at

Table 1. Type of SM analysis, comparison group, and other treatments provided for all 41 studies.

Authors	SM analysis (between subjects/within subjects)	SM compared to	Other treatments provided to those who received SM
Abrams and Wilson	Within	N/A	N/A
Aharonovich et al.	Between	MI-only group	MI
Aharonovich et al.	Within	N/A	MI
Aharonovich et al.(a)	Between	Education-only control group MI-only group	MI
Aharonovich et al.(b)	Between	MI-only group	MI
Bewick et al.	Within	N/A	Half received a personalized feedback intervention (PFI)
Buu et al.	Between	Compared daily v. weekly and IVR v. EMA	N/A
Fredericksen et al.	Within and Between	Three SM groups: Daily, Weekly, Event-Triggered	N/A
Harris and Miller ^a	Between	No-treatment waitlist	N/A
Hasin et al.	Between	Education/advice-only group and MI-only group	MI
Helzer et al.	Within	N/A	N/A
Helzer et al.	Between	Brief alcohol intervention (BAI) group	Three SM groups were collapsed for this review: (1) SM only; (2) SM + mailed feedback; (3) SM + mailed feedback + compensation
Hufford et al.	Within	N/A	N/A
Johnson et al.	Within	N/A	N/A
Karoly ^b	Within	N/A	N/A
Kennedy et al.	Between	Alcohol Discussion Group	6 Bi-weekly "SM Group Meetings" where rationale and strategies for using SM were discussed
Kilman et al.	Within	N/A	N/A
Lamontagne et al. ^c	Within	N/A	N/A
Lipinski et al.	Within	N/A	N/A
Maas et al. ^d	Within	N/A	N/A
Magnan et al.	Between	No-SM control group	N/A
McCarthy et al.	Between	Low-frequency SM to high-frequency SM	Three 15–20-min individual Clinical Practice Guideline-based smoking cessation counseling sessions
McCarthy et al.	Between	28 vs. 49 days of SM	Counseling and 1/2 of sample got nicotine replacement therapy (NRT)
McFall	Within	N/A	N/A
Moore et al.	Between	No-SM control group	All participants enrolled in intensive substance use outpatient program
Moss et al. ^e	Between	Two non-SM control group; one with delayed treatment and one with nicotine fading treatment (collapsed)	N/A
Ogborne and Annis ^f	Between	Non-SM control group	Half received intensive follow-up from a counselor and half had low follow-up
Reback et al. ^g	Between	Non-treatment control group	Participants had access to a dashboard that allowed them to review their EMA responses
Rosenberg	Between	Non-SM control group	N/A
Rowan et al. ^h	Between	Non-SM control group	Self-help materials + Nicotine patch
Samo et al.	Within	N/A	N/A
Schmitz et al.	Within	N/A	Methadone (low v. high dose)
Shiffman et al.	Between	Low frequency SM v. high frequency SM	Enrolled in a smoking cessation clinic
Simpson et al. ⁱ	Between	Non-SM control group	Recruited from treatment programs
Sobell et al.	Between	Non-SM control group	N/A
Suffoletto et al. ^j	Between	Non-SM control group	N/A
Sugarman ^k	Within	N/A	Two-thirds of participants received counseling/instructions
Tucker et al.(a)	Within	N/A	N/A
Tucker et al.(b)	Between	Non-SM control group	Optional weekly IVR-delivered educational modules
Walters et al.	Between	Non-SM control group	N/A
Wray et al.	Between	Non-SM control group	N/A

^aThis study compared 4 conditions: self-directed behavioral self-control training, therapist-directed behavioral control training, an SM-waitlist control, and a non-SM waitlist control. For the current review, only analyses examining the difference between the SM-waitlist control and the non-SM waitlist control were extracted.

^bThis study included a manipulation of High Expectancy (i.e., that SM would change behavior) vs. Low Expectancy, and compared SM of cigarettes smoked to craving. Analyses included in this review are based on analyses collapsed across groups; i.e., overall changes to SM in all groups.

^cAlthough this study also compared SM to acupuncture groups, the analysis from this review is regarding the within-persons reduction in cigarettes in the SM group.

^dAlcohol SM group was the control group in this study; the experimental group monitored snack-eating behavior. For this review, only data from the alcohol SM group are presented.

^eThis study had three SM groups (Group 1: time opening a new pack; Group 2: same as Group 1 + time each cigarette smoked; Group 3: same as Group 2 + brand of cigarette smoked, how much they smoked, who they were with, and how much each cigarette was enjoyed). For the purposes of this review, analyses comparing these groups to non-SM controls were extracted.

^fThis study used four groups: low follow-up + SM, intensive follow-up + SM, low follow-up w/o SM, and intensive follow-up w/o SM. Analyses collapsed across the follow-up conditions that compared SM to non-SM were extracted.

^gThis study also had a SM + dashboard + counseling group; only analyses focused on the comparison between the SM + dashboard group vs. the non-treatment control were extracted.

^hThis study had three groups: 1 week SM before quitting; 1 week SM after quitting, and no SM. Analyses reported in this review were only those comparing the two SM conditions (combined) to the no-SM group.

ⁱThis study also had a weekly monitoring condition. All results reported in this review were between daily SM and no SM.

^jStudy also had a SM + Feedback condition; not reported in this review.

^kSM group was considered the control condition for a study looking at SM vs. SM + Increased Strategies for Control. Analyses reported in this review are based on omnibus tests collapsed across groups and follow-up contrast tests looking at SM group alone vs. the null hypothesis.

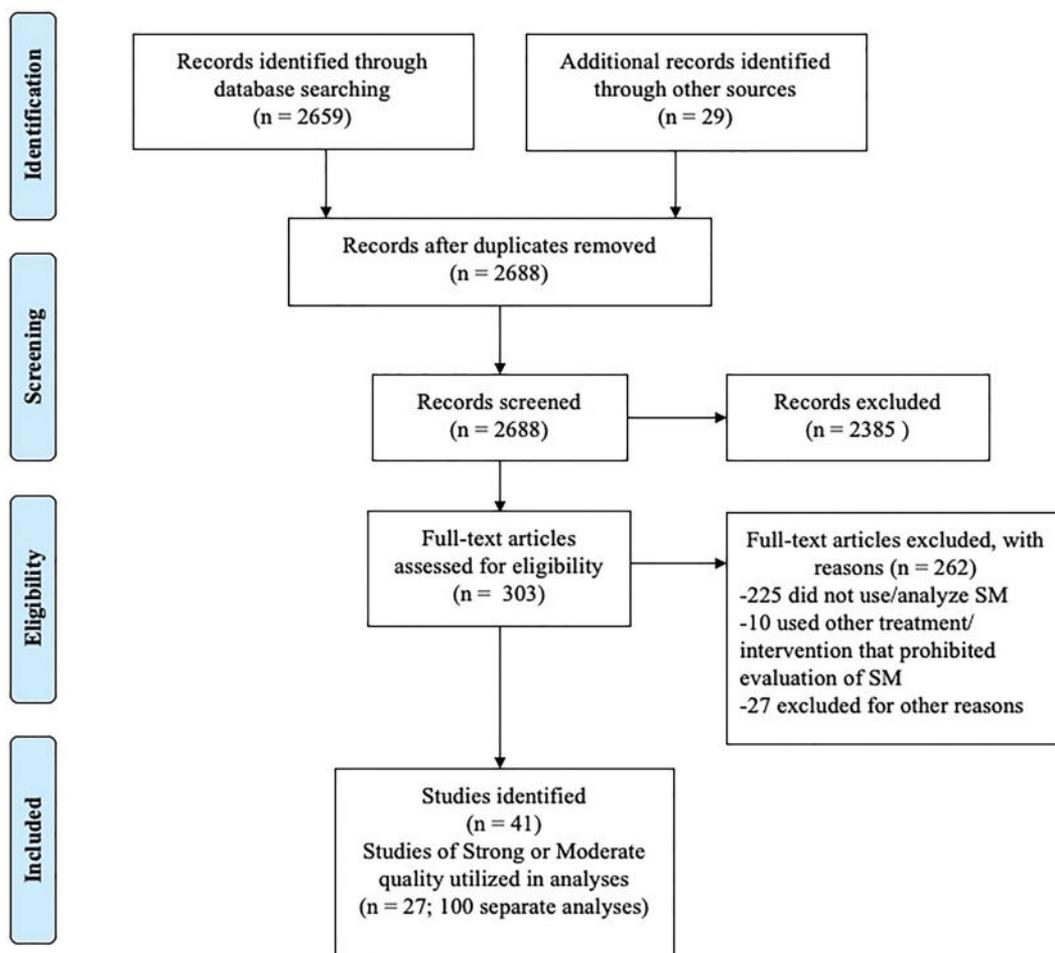


Figure 1. PRISMA⁴⁰ diagram showing study inclusion flow.

the analysis level. Thus, a single study could contribute multiple different analyses (e.g., one study might examine consumption, craving, and motivation to change, respectively). We also completed an adjunctive analysis wherein we calculated within each study how many analyses showed SM to be helpful, detrimental, or have no effect, with the total number of analyses from that study as the denominator. We computed the mean of those percentages within each outcome type, a figure that represents the average level of helpfulness, harmfulness, and no effect of SM within studies.

For all evaluations, the number of analyses was converted to a percentage of the total number of analyses within that unit of observation in order to most easily interpret the results across disparate numbers of analyses between predictors. Differences of greater than 7% are discussed as possible “notable” trends, as a sensitivity analysis conducted in G*Power3.1 indicated that for a two-tailed test of proportionality with the average number of included analyses, a 7% difference between groups would yield significance at $\alpha = .05$.

Results

Figure 1 presents the diagram for study selection informed by Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines.^{40,41} Identified studies ($n = 41$) included 6,031 participants (median = 72.5, range = 5–1,478;

age $M = 34.2$, $SD = 12.8$; 59% white, 57.6% male). Seventeen (41.4%) articles focused exclusively on alcohol.^{22,24,37,42–55} 35.7% ($n = 15$) of articles evaluated tobacco use alone.^{23,25,38,56–67} Nine (21.9%) looked at a mix of other substances (some articles in this section included both alcohol and other substances).^{51,68–75} For studies that included both alcohol and other drugs (e.g., Buu et al.⁷⁶), results from separate analyses were included for each respective substance.

Study quality

A total of 3 articles were classified as having used strong methodology, 24 were classified as moderate, and 14 were classified as weak. By substance type, quality ratings were as follows: (1) alcohol-only studies: 6 weak, 12 moderate, 0 strong; (2) tobacco-only studies: 8 weak, 5 moderate, 2 strong; and other drugs/various: 0 weak, 7 moderate, 1 strong. The rest of the analyses will be restricted to those studies with strong or moderate methodological quality (27 studies, 100 analyses).

Study characteristics

A total of 12 studies included participants who were actively quitting or cutting down or enrolled in a treatment

program; and 15 studies examined those who were not explicitly treatment-seeking. Across 100 analyses, 47% evaluated substance consumption other than explicit lapse/relapse during a quit attempt, 11% evaluated lapse/relapse as part of a quit attempt, and 42% evaluated a non-consumption outcome (e.g., craving ratings, withdrawal, motivation to quit, etc.). Table 2 presents the study characteristics.

Self-monitoring characteristics

Four studies (14.8%) utilized “paper and pencil” type diary assessments as the primary format of SM; 37.0 ($n = 10$) used IVR or telephone; 44.4% ($n = 12$) used some type of EMA device (e.g., a palm pilot or smartphone) or computer; and 3.7% ($n = 1$) compared EMA to IVR.⁷⁶ The median time that participants engaged in SM was 49 days (range: 7–720 days), and a majority (85%) of SM protocols had participants monitoring behavior at least daily during the SM period (exceptions included three days/week, weekly, monthly, and quarterly SM); one study compared daily monitoring to weekly.⁷⁶ During SM assessments, 13% of studies had participants simply monitor their consumption of the target substance (i.e., if/when/how much they consumed), whereas the majority (87%) of studies asked participants to monitor more than just consumption.

Effects of SM on substance use-related outcomes

SM had a helpful effect on outcome 29.0% of the time (29 analyses), had no effect in 63.0% of analyses (63 analyses), and a detrimental effect in 8.0% (8 analyses). See Table 3 for a summary of all analyses and outcomes and see Table 4 for a summary of all outcomes. SM showed a helpful effect in analyses from 15 of the 27 studies rated as strong or moderate quality.^{24,38,42–44,47,55,59,61,62,66,70,73,75,76}

Substance type

There were 41 analyses looking at alcohol use outcomes, 40 looking at tobacco use outcomes, and 19 looking at other substances. SM had a helpful effect in 25.0% ($n = 10$) of analyses with tobacco outcomes, 36.6% ($n = 15$) of analyses with alcohol outcomes, and 21.1% ($n = 4$) of analyses with other substance outcomes. Detrimental effects were observed in 5 analyses with alcohol and 3 with tobacco (Figure 2).

Sample type

SM had no effect in most analyses in the treatment-seeking group ($n = 44$ analyses, 73.3%), followed by a helpful effect ($n = 15$, 25.0%) and a detrimental effect ($n = 1$, 1.7%). In the non-treatment-seeking analyses, 47.5% ($n = 19$) showed no effect, followed by 35.0% of studies ($n = 14$) showing a helpful effect and 17.5% ($n = 7$) showing a detrimental effect. Regarding helpful effects, the difference between treatment-seeking and non-treatment seeking was 10%, which was above the established benchmark for a notable effect in this review.

Characteristics of SM

Regarding mode of SM, helpfulness was more often seen in analyses using computer/EMA (28.8% analyses with computer/EMA were shown to be helpful; $n = 17$) and phone/IVR (33.3%, $n = 9$) than paper/pencil (20.0%, $n = 2$) though of note there were fewer paper/pencil diary analyses evaluated from studies with moderate or strong quality ($n = 10$; See Figure 3). Just under the 7% benchmark for a notable effect, studies where SM measured more than just consumption were slightly more likely to be helpful (29.9%, $n = 26$) than those that only measured consumption (23.1%, $n = 3$), though because of the few analyses that only measured consumption only ($n = 13$), this finding may be an artifact of sample size. There was a higher proportion of analyses showing a helpful effect in studies with > 6 weeks of SM (40.0%, $n = 16$) than analyses from studies with shorter periods (0–3 weeks: 18.2%, $n = 6$; 3–6 weeks: 25.9%, $n = 7$). Regarding whether participants were compensated for completing SM or not, we found that a majority of strong/moderate studies did not compensate or did not report compensating ($n = 16$). We found that in studies not reporting/not compensating, SM was more likely to have a helpful effect (33.3% of analyses) than in studies that did compensate (22.9% of analyses).

Adherence

Twenty-two strong/moderate studies reported on adherence to SM in some way. We calculated split-half adherence to be 70.9% and classified studies with $\geq 70.9\%$ as having greater adherence. SM was more helpful in studies where participants had greater adherence ($n = 11$; 36.7% of analyses) compared to those with poorer adherence ($n = 7$; 20.0% of analyses).

Outcome evaluated

See Tables 3 and 4 for the list of outcomes. Only one of eleven analyses that examined SM’s effect on lapse/relapse as part of a quit attempt was found to be helpful, 38.3% ($n = 18$) showed SM had a helpful effect when examining consumption not part of an active quit attempt, and 23.8% ($n = 10$) showed a helpful effect in non-consumption outcomes (See Figure 4).

Comparison group

Studies that directly compared SM to something else (typically, a non-SM control group, Table 1) showed SM to be helpful in only 25.9% ($n = 21$) of analyses, while studies without a comparison group that used a within-persons design showed SM to be helpful in 42.1% ($n = 8$) of analyses.

Additional treatment

Studies wherein participants using SM also received other treatments showed SM to be helpful in only 21.5% of analyses ($n = 15$), whereas studies where SM participants did not

Table 2. Study characteristics and quality ratings of all 41 studies.

Authors	Year	N	Substance	Treatment seeking (Y/N)	Days of SM	Frequency and format of SM	SM Assessments (JC = just consumption, C+ = more than consumption assessed)	Reported compensation for SM (Y/N)	Was SM compliance reported? (Y/N: % compliance reported or calculated)	Quality (S = Strong, M = Moderate, W = Weak)
Abrams and Wilson	1979	40	Tobacco	Y	28	Daily	JC	N	N	W
Aharonovich et al.	2012	33	Various substances	N	60	Daily	C+	N	Y: 58%	M
Aharonovich et al. ^a	2006	31	Alcohol; various substances	Y	60	Daily	C+	N	Y: 76.9%	M
Aharonovich et al.(a)	2017	240	Various substances	Y	60	Daily	C+	N	Y: 64.1% (median)	M
Aharonovich et al.(b)	2017	42	Alcohol; various substances	Y	60	Daily	C+	N	Y: 64.1% (median)	M
Bewick et al.	2013	1478	Alcohol	N	238	Quarterly	C+	N	Y: 65%	M
Buu et al.	2019	307	Alcohol/marijuana	N	90	Daily v. weekly	JC	N	Y: 83%	M
Fredericksen et al. (Study 1 = S1; Study 2 = S2)	1975	51 = 15 52 = 36	Tobacco	N	28	Three groups: DAILY, Weekly, event-triggered	JC	N	N	W
Harris and Miller	1990	34	Alcohol	Y	42 to 140	Daily	JC	N	Y: 75% during treatment period; 55% during followup period	M
Hasin et al.	2013	258	Alcohol	N	60	Daily	C+	N	Y: 64.4%	M
Heizer et al.	2002	33	Alcohol	N	720	Daily	C+	Y	Y: 91.7%	M
Heizer et al.	2008	338	Alcohol	N	180	Daily	C+	Y ^b	Y: 68%	M
Hufford et al.	2002	33	Alcohol	N	14	Daily	C+	N	Y: 86%	M
Johnson et al.	2009	248	Alcohol	N	7	Daily	C+	N	Y: 78%	M
Karoly	1975	56	Tobacco	N	28	Daily	C+	N	N	W
Kennedy et al.	1978	20	Alcohol	Y	21	Hourly	C+	N	N	W
Kilman et al.	1977	89	Tobacco	N	28	Daily	JC	N	N	W
Lamontagne et al.	1980	75	Tobacco	Y	14	Daily	JC	N	N	M
Lipinski et al.	1975	36	Tobacco	18 Y 18 N	28	Daily	JC	N	N	W
Maas et al.	2013	33	Alcohol	N	15	Daily	JC	N	Y: 100%	M
Magnan et al.	2013	117	Tobacco	N	14	Daily	C+	N	Y: 84.8	M
McCarthy et al.	2015	110	Tobacco	Y	28	Daily	C+	N ^c	Y: 78.2% in low frequency group; 90.8% in high frequency group	S
McCarthy et al.	2006	70	Tobacco	Y	28 vs. 49	Daily	C+	N ^d	Y: 80.3%	S
McFall	1970	16	Tobacco	N	13	3 days/week	JC	N	N	W
Moore et al.	2014	101	Various	Y	120	Daily	C+	Y	Y: 42.3%	M
Moss et al.	1982	50	Tobacco	Y	28	Daily	C+ ^e	N	N	W
Ogborne and Annis	1988	144	Alcohol	Y	365	Daily	JC	N	Y: 38%	W
Reback et al.	2018	136	Methamp-hetamine	Y	56	Daily	C+	Y	N	S
Rosenberg	1988	29	Alcohol	N	90	Event-triggered	JC	N	N	W
Rowan et al.	2007	97	Tobacco	Y	7	Daily	C+	Y	Y: 65.1%	M
Samo et al.	1989	14	Alcohol	N	21	Daily	JC	Y	Y: cannot calculate	W
Schmitz et al.	1994	5	Tobacco	N	14	Hourly	JC	Y	Y: cannot calculate	W
Shiffman et al.	1997	214	Tobacco	Y	Up to 26	Daily	C+	N	N	M
Simpson et al.	2005	98	Alcohol, various substances	Y	28	Daily	C+	Y	Y:77.9%	M
Sobell et al.	1989	69	Alcohol	N	14	Daily	JC	N	Y	W
Suffoletto et al.	2015	765	Alcohol	N	84	Weekly	JC	N	N	M
Sugarman	2009	177	Alcohol	N	14	Daily	C+	N	N	M
Tucker et al.(a)	2012	54	Alcohol, various substances	N	28 and 70	Daily	C+	Y	Y: 46.9%	M
Tucker et al. (b)	2012	185	Alcohol	Y	168	Daily	C+	Y	Y: cannot calculate	W

(continued)

Table 2. Continued.

Authors	Year	N	Substance	Treatment seeking (Y/N)	Days of SM	Frequency and format of SM	SM Assessments (JC = just consumption, C+ = more than consumption assessed)	Reported compensation for SM (Y/N)	Was SM compliance reported? (Y/N: % compliance reported or calculated)	Quality (S = Strong, M = Moderate, W = Weak)
Walters et al.	2009	147	Alcohol	N	365	Quarterly	Comp-uter	Y	N	M
Wray et al.	2015	176	Tobacco	N	28	Daily	IVR	Y	Y: 94%	M

Notes: SM: Self-monitoring; IVR: Interactive Voice Recording; EMA: Ecological Momentary Assessment; MET: Motivational Enhancement Therapy; PFI: Personalized Feedback Intervention; BI: Brief Intervention; VA: Veteran's Affairs; VAMC: VA Medical Center.

^aQuality raters for this article initially discrepant on variable assessing participant withdrawal from the study. Withdrawals increased over the course of the study and by end of study only 18 of 31 participants remained, which would have rendered this a Weak rated article. However, most analyses reported in this review are from the first 60 days of the study, which included 24 of 31 participants, moving this into the Moderate quality category.

^bThis study compared three SM groups to a brief alcohol intervention control; only one SM group used compensation.

^cParticipants were not compensated for SM directly, they were compensated for returning their diaries at the end of the study period.

^dSame as Footnote c.

^eThis study had two JC conditions and one C + condition.

receive treatment showed SM to be helpful in 46.7% of analyses ($n = 14$).

Study-level analysis

When we computed the percentage of each outcome (helpful, no effect, detrimental) within each study, we found that on average, SM helpfulness was 33.4%, no effect was 53.0%, and harmfulness was 12.6%.

Discussion

SM is a low cost, low intensity intervention that is commonly used by providers as a component of many behavioral change treatments that are highly accepted by patients,⁸⁵ but has had inconclusive findings within the context of substance use. A primary finding of this review is the relatively low frequency of analyses that showed a detrimental effect of SM on any substance use-related outcome—8 of the 100 (8.0%) analyses of moderate to strong quality showed a detrimental effect of any kind. In addition, detrimental effects often had theorized explanations other than SM actually being harmful (e.g., rather than SM increasing substance use, it increased accuracy of reporting compared to non-SM groups^{45,67}; SM reduced readiness to change in two studies but also showed that substance use levels decreased, which may have led to less of a perceived need to change^{46,61}). However, it is possible that the detrimental effects cannot be alternatively explained; that is, that SM did have a true detrimental effect in these studies. It was notable that studies showing a detrimental effect only occurred in alcohol/tobacco studies, which may suggest a qualitative difference between those and illicit/illegal drugs. Due to the infrequency of SM having a detrimental effect, the small size of any detrimental effect identified, and the potential for it to produce a positive outcome in approximately 1/3 of studies across different substances, we believe that SM is a low cost, low intensity intervention that can be safely utilized for research and clinical applications in substance using individuals.

SM may work best as an intervention component for pre-quit processes, which is a situation where clinicians have few alternative evidence-based interventions that can be easily incorporated with MI techniques. This review found that non-quitting consumptive behaviors were positively influenced by engaging in SM in 39.3% of analyses from moderate and strong quality studies. This result spanned across studies on tobacco, alcohol, and illicit drugs.^{24,42–44,47,61,63,68,73,75} This is in line with theories of behavior change, which suggest that awareness of a behavior and processes related to the behavior is key *early* in the process of behavior change (e.g., Health Action Process Approach model, Transtheoretical Model).^{74,86} Thus, SM may be particularly useful for increasing pre-quit awareness of behaviors and behavioral cues related to substance use, which is an important step in the continuum of behavior change. This is similar to research in other areas—SM studies examining weight/exercise have also found that pre-

Table 3. Results for each analysis from strong and moderately rated studies.

Study	(Analysis number) outcome	SM effect on outcome
Aharonovich et al. (2012)	(1) Substance use at end of SM period	No effect
	(2) Substance use 30 days post-SM	No effect
Aharonovich et al. ⁶⁸	(3) Drinking days during SM period	Helpful
	(4) Cocaine use during SM period	Helpful
	(5) Drinking days halfway through SM period	No effect
Aharonovich et al. ⁶⁹	(6) Highest number drinks/day	Helpful
	(7) End of treatment substance using days	No effect
	(8) 6-months post treatment substance using days	No effect
	(9) 6-months post treatment quantity of substance consumed	No effect
	(10) 12-months post treatment substance using days	No effect
Aharonovich et al. ⁷⁵	(11) 12-months post treatment quantity of substance consumed	No effect
	(12) Attrition from treatment	No effect
	(13) Substance use days during SM period	Helpful
	(14) \$ spent on primary substance	Helpful
	(15) Alcohol use during SM period	No effect
Bewick et al. ⁴²	(16) Number of standard drinks per drinking day	No effect
Buu et al. ⁷⁶	(17) Past 7 day quantity of drinks consumed	Helpful
	(18) Alcohol consumed (Week 1)	Helpful
	(19) Alcohol consumed (entire study period)	No effect
	(20) Marijuana consumed (Week 1)	No effect
Harris and Miller ⁴³	(21) Marijuana consumed (entire study period)	No effect
	(22) Weekly alcohol consumption, total	No effect
	(23) Peak BAC	Helpful
Hasin et al. ⁴⁴	(24) Number of drinks per day during SM period	Helpful
	(25) Percent days abstinent during SM period	No effect
Helzer et al. ²⁴	(26) Mean daily consumption over 2-year SM period	Helpful
	(27) Drinks per day between Year 1/Year 2	Helpful
	(28) Drinking days/week between Year 1/Year 2	Helpful
	(29) Drinks/drinking day comparing Year 1/Year 2	Helpful
Helzer et al. ⁴⁵	(30) Past 3-months days/drinks consumed at 6-month followup	Detrimental
	(31) Past 6-months days/drinks consumed at 6-month followup	Detrimental
Hufford et al. ⁴⁶	(32) Mean number drinks/week	No effect
	(33) Drinking days	No effect
	(34) Readiness to change	Detrimental
Johnson et al. ⁴⁷	(35) Alcohol use over 7 day SM period	Helpful
Lamontagne et al. ⁵⁹	(36) CPD post-treatment	Helpful
Maas et al. ³⁷	(37) Alcohol quantity/frequency during SM period	No effect
Magnan et al. ⁶¹	(38) CPD during SM period	Helpful
	(39) Perceived risk of developing a smoking-related medical condition	Detrimental
McCarthy et al. ⁶²	(40) 7-day point prevalence abstinence	No effect
	(41) 28-day point prevalence abstinence	No effect
	(42) Craving to smoke	Helpful
	(43) Sadness	Helpful
	(44) Anxiety	Helpful
	(45) Anger	Helpful
	(46) Hunger	No effect
	(47) Positive affect	Detrimental
	(48) Motivation to quit	No effect
McCarthy et al. ²⁵	(49) Quitting confidence	No effect
	(50) WSWS	No effect
	(51) Negative affect	No effect
	(52) Abstinence	No effect
	(53) Hunger	No effect
	(54) Craving to smoke	No effect
Moore et al. ⁷¹	(55) Relapse to given substance of abuse	No effect
Reback et al. ⁷²	(56) Methamphetamine use	No effect
Rowan et al. ^{38a}	(57) Anger	No effect
	(58) Anxiety	Helpful
	(59) Sadness	No effect
	(60) Concentration	Helpful
	(61) Craving	No effect
	(62) Hunger	No effect
	(63) Sleep	Helpful
	(64) Positive Affect	No effect
	(65) Negative Affect	No effect
	(66) Negative Affect	No effect
	(67) Pleasure	No effect
	(68) Social Image	No effect
	(69) Social Influence	No effect
	(70) Diet Concerns	No effect
	(71) Pros of smoking	No effect
	(72) Cons of smoking	No effect
	(73) Positive/Social temptations	No effect
	(74) Negative/Affective temptations	No effect
	(75) Habit/Addictive temptations	No effect

(continued)

Table 3. Continued.

Study	(Analysis number) outcome	SM effect on outcome	
Shiffman et al. ⁶⁶	(76) Temptation episodes	Helpful	
	(77) Urges	No effect	
Simpson et al. ¹³	(78) Days drinking	No effect	
	(79) Total standard drink units	No effect	
	(80) Craving	No effect	
	(81) Cocaine use	No effect	
	(82) Marijuana use	No effect	
Suffoletto et al. ⁵²	(83) Binge drinking prevalence	No effect	
	(84) Drinks per drinking day	No effect	
	(85) Days with binge drinking	No effect	
	(86) Alcohol-related injuries	No effect	
Sugarman and Carey ⁵³	(87) Drinks per week	No effect	
	(88) Average BAC	No effect	
	(89) Heaviest BAC	Detrimental	
	(90) Use of selective avoidance to limit drinking	No effect	
	(91) Overall use of strategies to limit drinking	Detrimental	
	(92) Use of alternatives to limit drinking	No effect	
	Tucker et al. ⁵⁴	(93) Illicit substance use during SM period	Helpful
		(94) Drinking during SM period	No effect
	Walters et al. ⁵⁵	(95) Overall alcohol use during SM period	No effect
		(96) Risky drinking during SM period	Helpful
(97) AUDIT		Helpful	
(98) Peak BAC		Helpful	
Wray et al. ⁶⁷	(99) Use of coping behaviors to reduce drinking	Helpful	
	(100) CPD during SM period	Detrimental	

Notes: SM: self-monitoring; CPD: cigarettes per day; TLFB: Timeline Followback⁸²; BAC: Blood Alcohol Content; RTC: return to clinic; \$: money; WSWs: Wisconsin Smoking Withdrawal Scale;⁷⁷ DPD: drinks per day; AUDIT: Alcohol Use Disorder Identification Test;⁸³ AUDC: Alcohol Use Disorder Identification Test—Consumption Items.⁸⁴

^aSubscales in analyses 78–84 came from the WSWs⁷⁷; 85–86 from the Positive and Negative Affect Scale;⁷⁸ 87–91 from the Self-Efficacy Scale,⁷⁹ 92–93 from the Decisional Balance Inventory—Short Form;⁸⁰ 94–96 from the Situational Temptation Inventory.⁸¹

Table 4. Summary table of results from Strong and Moderate studies.

	Number of analyses (N) in subcategory	Percentage of analyses (N) by outcome		
		No SM effect	Helpful SM effect	Detrimental SM effect
Substance type				
Alcohol	41	51.2 (21)	36.6% (15)	12.2% (5)
Tobacco	40	67.5% (27)	25.0% (10)	7.5% (3)
Other drugs	19	78.9% (15)	21.1% (4)	0% (0)
Sample type				
Treatment-seeking	60	73.3% (44)	25.0% (15)	1.7% (1)
Non-treatment-seeking	40	47.5% (19)	35.0% (14)	17.5% (7)
Outcome evaluated				
Lapse/relapse as part of active quit/reduction	11	90.9% (10)	9.1% (1)	0% (0)
Substance use not including lapse/relapse	47	53.2% (25)	38.3% (18)	8.5% (4)
Non-consumption outcomes	42	66.7% (28)	23.8% (10)	9.5% (4)
SM analysis type				
Comparison group (between subjects)	81	67.9% (55)	25.9% (21)	6.2% (5)
No comparison group (within-subjects)	19	42.1% (8)	42.1% (9)	15.8% (3)
Other treatments received				
None	30	43.3% (13)	46.7% (14)	10.0% (3)
Additional treatments received	70	71.4% (50)	21.4% (16)	7.1% (5)
Mode of self-monitoring ^b				
Phone/IVR	27	55.6% (15)	33.3% (9)	11.1% (3)
EMA/computer	59	66.1% (39)	28.8 (17)	5.1% (3)
Paper and pencil diary	10	60.0% (6)	20.0% (2)	20.0% (2)
Intensity of self-monitoring				
Just consumption assessed	13	69.2% (9)	23.1% (3)	7.7% (1)
More than consumption assessed	87	62.1% (54)	29.9% (26)	8.0% (7)
Length of monitoring period ^a				
0–3 weeks	33	69.7% (23)	18.2% (7)	12.1% (4)
3–6 weeks	27	66.7% (18)	25.9% (7)	7.4% (2)
>6 weeks	40	55.0% (22)	40.0% (16)	5.0% (2)
Compensated for completing SM ^c				
Yes	35	68.6% (24)	22.9% (8)	8.6% (3)
No/Not reported	63	61.9% (39)	33.3% (21)	4.8% (3)
Adherence to SM ^d				
≥70.9% SM adherence	30	53.3% (16)	36.7% (11)	10.0% (3)
<70.9% SM adherence	36	72.2% (26)	22.2% (8)	5.6% (2)

Notes: ^aFor length of monitoring period, two studies compared longer v. shorter periods.^{25,73} Because the longer period exceeded 6 weeks, these studies are represented in the >6 weeks subcategory. A study⁷⁶ examined outcomes after 7 days of SM and then after 90 days; these effects are represented in the table in the subcategory corresponding to the weeks of SM being evaluated. ^bA study⁷⁶ used both EMA and IVR; that study is not included in the mode of SM portion of this table. ^cA study⁴⁵ used compensation as a manipulation; this study was not included in the analyses on compensation. ^d70.9% was chosen as cutoff because it was the mean of all studies that reported adherence. One study⁶² was not included in compliance analyses as adherence varied between two SM (low intensity v. high intensity) comparison groups.

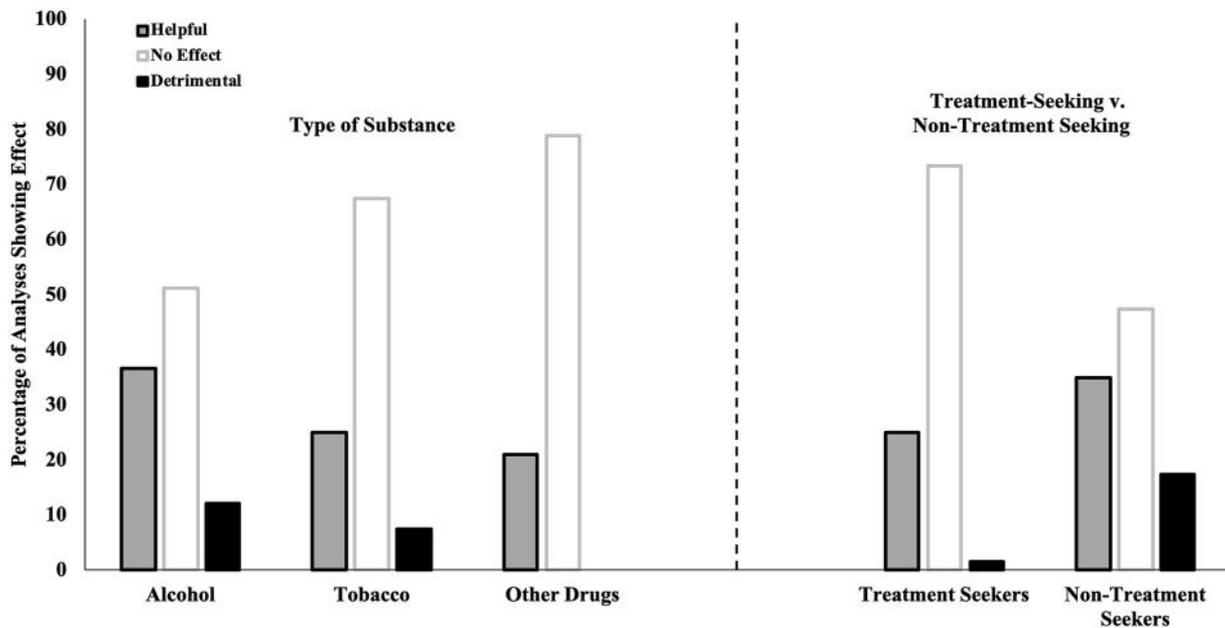


Figure 2. Percentage of analyses with each SM effect based on sample features. Percentage were calculated within each group within a subtype (e.g., columns in "Treatment Seekers" would equal 100%).

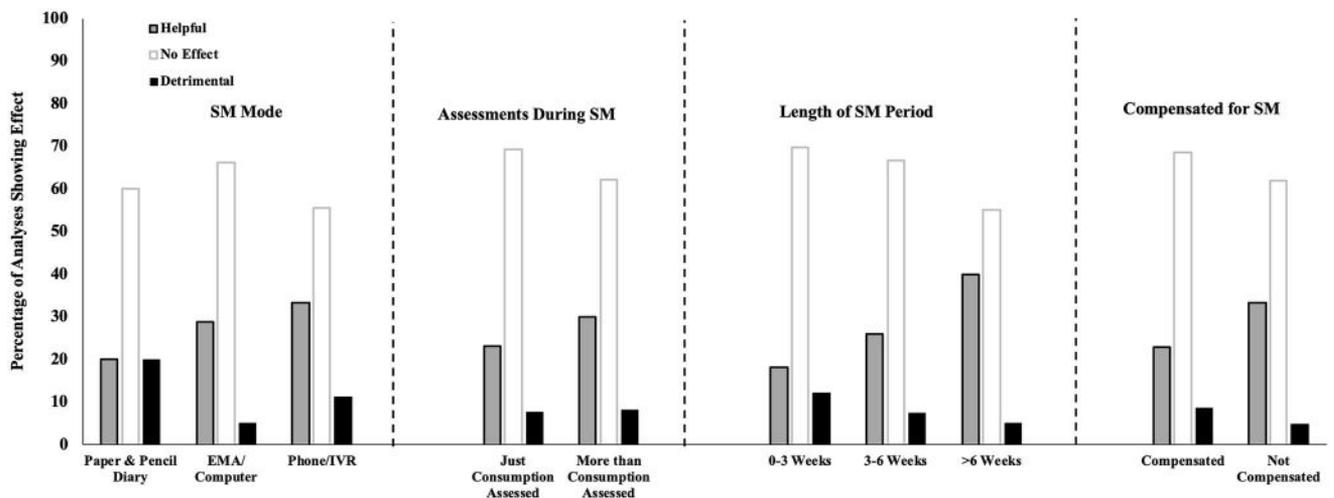


Figure 3. Percentage of analyses with each SM effect based on features of the SM protocol. Percentage were calculated within each group within a subtype (e.g., columns in "Phone/IVR" would equal 100%).

behavior change monitoring can improve the success of behavior change.^{26,87} Additionally, for substance users in an earlier stage of change, it is possible that SM helps to resolve ambivalence about changing. In this regard, the MI literature suggests that ambivalence is a central feature of hesitation to change a behavior, and resolving ambivalence can lead to taking action to change that behavior.⁸⁸ Therefore, a low-intensity, non-change based intervention like SM may benefit participants at an earlier stage of change by resolving ambivalence, but those who are further along the change continuum, such as individuals engaged in a cessation program, may be less influenced by SM because they are less ambivalent about changing their behavior.

Although these findings should be interpreted with caution, given that we did not use a meta-analytic procedure, our review also suggests that the following may improve the

likelihood of SM's helpfulness: (1) asking patients to engage in SM for greater than six weeks; (2) use of EMA/computer or phone/IVR compared to paper; (3) not using compensation, (4) focusing on alcohol users. Consistent with research examining SM's effect on other health behaviors (e.g., exercise or calorie consumption),^{9,26,89,90} extending the length of the SM period may provide more opportunities for individuals to observe and subsequently reduce substance use. Future research needs to provide greater clarity on the ideal timeframe for optimal SM benefits, due to the variation in timeframes from six weeks to two years of included studies and confirm the importance of tracking more than just consumption due to the uneven sample sizes within this review. Regarding the use of compensation, theories of motivation suggest that more intrinsically motivated behaviors are more influential on motivation to change,³⁵ which may explain

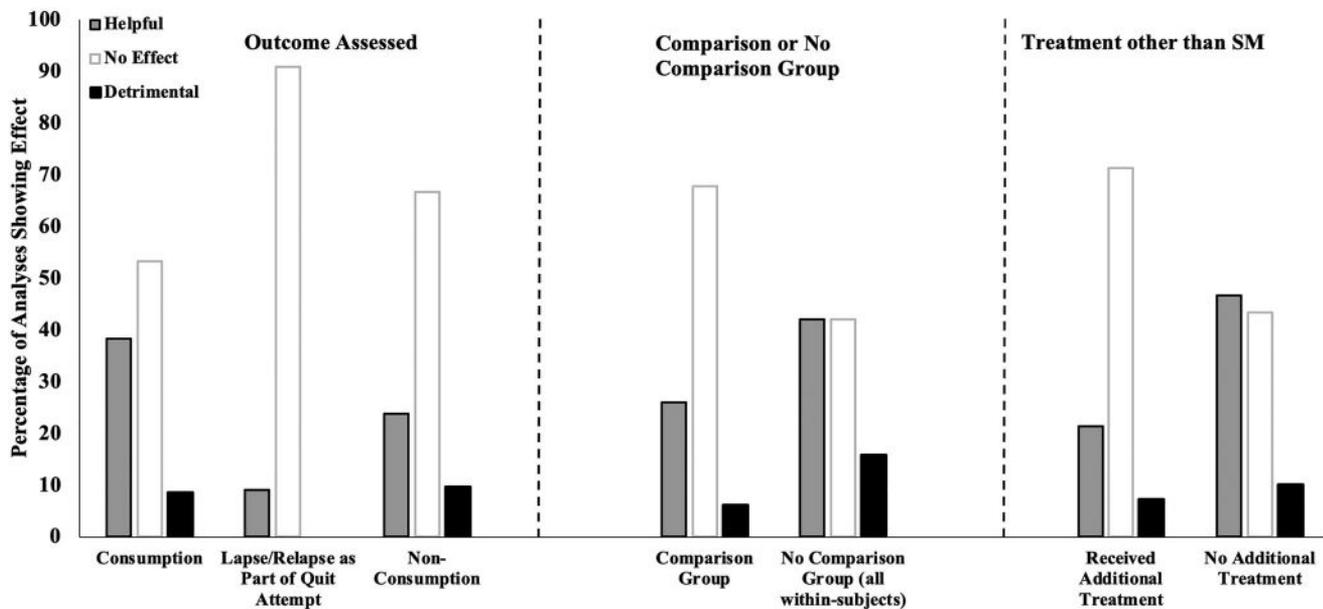


Figure 4. Percentage of analyses with each SM effect based on outcome being assessed, type of analysis (i.e., comparison or no comparison), and provision of other treatment. Percentage were calculated within each group within a subtype (e.g., columns in “Consumption” would equal 100%).

the observed increase in positive outcomes among participants from studies that did not use compensation.

Although it was unexpected compared to previous research examining SM in hypertension,⁹¹ SM was notably less likely to have a helpful effect when compared to studies where participants did receive additional treatment. Future research can provide greater clarity, as it is possible that this finding was due to uneven cell sizes when making the comparisons or confounded by either participant/recruitment categories (i.e., many studies that included additional treatments were among treatment-seekers, who we observed were less likely to be positively affected by SM), or elements of the design (e.g., SM’s effect is masked by the other treatment).

Overall, there are several reasons why this review did not strongly support using SM with the goal of influencing substance use-related outcomes, though as a data collection method or as an intervention for pre-quit processes, SM poses little threat in clinical practice or research. Studies using a single-arm within-person design were more likely to show SM being helpful than those with an explicit between-person SM comparison. This is likely due to the fact that within-persons designs tend to show stronger effect sizes due to reduced heterogeneity,⁹² but are methodologically weaker than a randomized between-groups manipulation when attempting to understand the effect of an intervention, as one would use in a RCT. Importantly, a single group within-subjects design can be confounded by the passage of time. In addition, it was relatively rare to find eligible articles for this review; though many studies include SM as part of their study/intervention design (see Figure 1), few explicitly evaluated the effect of SM on some target outcome. Within this review, three moderate/strong studies contributed to the 29.7% of the helpful effects,^{24,55,62} giving these studies disproportionate influence on our results. Finally, in this review, we collapsed results examining

sample features and SM attributes across the substance use categories (i.e., tobacco, alcohol, other/mixed). Other predictors may have varied across substance type. For instance, when looking at tobacco studies, we see that SM was helpful in only two studies with consumption outcomes, whereas for alcohol/other drugs, consumption SM was helpful in 12 and 5 analyses, respectively.

Conclusions

Overall, the current systematic review identified 41 studies evaluating SM on substance use outcomes. Just under one-third of analyses showed that self-monitoring substance use had a beneficial effect. Despite mixed findings, this review provides some support for the use of SM in research and clinical applications as it can be low cost and minimally intensive yet still produce positive benefits to substance users, particularly for drinkers who are not seeking cessation treatment, and has the greatest likelihood of being helpful when using. SM clearly has a role to play during substance use behavior change, and future research is needed to disentangle the complexities of its effect on substance use.

Acknowledgments

The authors would like to thank the Center for Integrated Healthcare SERVICE Lab Support Staff, especially Jacob Scharer, Yvette Rother, Lee Bernstein, Jennie Tapio, Taylor Larobardiere, Jillian Avery, and Michael Paladino, for their help with this research.

Disclosure statement

The views expressed in this article are those of the authors alone and do not represent the US Federal Government or the Department of Veterans’ Affairs. The authors have no financial conflicts of interest to disclose.

Funding

Writing of this manuscript was supported in part by the Department of Veterans Affairs Office of Research and Development, Health Services Research & Development Career Development Award Program; the Department of Veterans Affairs Office of Academic Affiliations, Advanced Fellowship Program in Mental Illness Research and Treatment, the Department of Veterans Affairs Center for Integrated Healthcare, VA Western New York Healthcare System at Buffalo, and the Department of Veterans Affairs Office of Research and Development.

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