REVIEW

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Mindfulness and Behavior Change

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Abstract: Initiating and maintaining behavior change is key to the prevention and treatment of most preventable chronic medical and psychiatric illnesses. The cultivation of mindfulness, involving acceptance and nonjudgment of present-moment experience, often results in transformative health behavior change. Neural systems involved in motivation and learning have an important role to play. A theoretical model of mindfulness that integrates these mechanisms with the cognitive, emotional, and self-related processes commonly described, while applying an integrated model to health behavior change, is needed. This integrative review (1) defines mindfulness and describes the mindfulness-based intervention movement, (2) synthesizes the neuroscience of mindfulness and integrates motivation and learning mechanisms within a mindful self-regulation model for understanding the complex effects of mindfulness on behavior change, and (3) synthesizes current clinical research evaluating the effects of mindfulness-based interventions targeting health behaviors relevant to psychiatric care. The review provides insight into the limitations of current research and proposes potential mechanisms to be tested in future research and targeted in clinical practice to enhance the impact of mindfulness on behavior change.

Keywords: health behavior, mental disorders, mindfulness, motivation, neuroscience, self-management, self-regulation

INTRODUCTION

Health behavior refers to any behavior that affects physical or mental health or quality of life.[1] Unhealthy behaviors such as tobacco smoking, alcohol and substance use, excessive eating, and nonadherence to medical regimens account for a substantial proportion of global disease morbidity and mortality, and for 40%–50% of the risk for early death in the United States.[2–6] All-cause mortality is inversely associated with healthy lifestyle behaviors, and changes in unhealthy behaviors can lead to improved physical and mental health outcomes.[7] Despite widespread awareness, it remains exceptionally difficult to initiate and maintain health behavior change.[2]

Health behavior theories are used to understand and predict health behaviors,[8–16] and several behavior-change interventions have become popular.[17,18] A growing body of evidence suggests that mindfulness-based interventions (MBIs) are effective in reducing harmful health behaviors,[19] catalyzing chronic disease self-management and health behavior change,[20] and improving physical and mental health outcomes.[21–23] This article provides a narrative review with three main aims: (1) to define mindfulness and describe the evolving context and content for the MBI movement, (2) to describe an updated "mindful self-regulation" model that integrates motivation and learning mechanisms essential for behavior change and is grounded in emerging neuroscientific evidence, and (3) to synthesize current clinical research on MBIs targeting health behaviors relevant to psychiatry.

MINDFULNESS AND MBIs

Mindfulness is commonly defined as the awareness that arises when paying attention to the present moment nonjudgmentally.[24] In 1881, the English scholar Rhys Davids translated the word *mindfulness* from the Pali word *sati* found in Buddhist texts, which meant "memory, recollection, calling-to-mind, being-aware-of, certain specified facts"[25] but which has also been described as "lucid awareness"[26] or "bare attention."[27]

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The terms *mindfulness* and *meditation* are increasingly conflated. General integrative practices (e.g., visualization, yoga) are often described as "mindfulness" in public discourse, diluting the word's meaning. Importantly, not all meditation is mindfulness and not all mindfulness is meditation. Meditation is a practice that self-regulates the body and mind by engaging a specific attentional set.[28] In *mindfulness meditation* (MM), the practice is to pay attention to present-moment experience with an orientation of curiosity, openness, acceptance, nonreactivity, and nonjudgment.[29,30]

Several core types of MM are taught in MBIs, along an attentional continuum that ranges from *focused attention*, which involves directing and sustaining attention on an object, disengaging from distractors (e.g., mind wandering), and returning attention to the object, to *open monitoring*, which has no explicit focus but cultivates metacognitive monitoring with a nonreactive awareness of the flow of cognition, emotions, and sensations.[31] MBIs also use other evocative meditations to cultivate specific emotions (e.g., compassion, loving-kindness) that support MM practice.[32,33] MM may produce relaxation in the body (i.e., the *relaxation response*, a voluntary, wakeful, hypometabolic state of parasympathetic dominance),[34] but relaxation is not necessarily the objective. Rather, MM is an active and intentional practice of cultivating awareness of present-moment experience that may include strong emotions, difficult thoughts, or unpleasant sensations.[35] MM cultivates both awareness and equanimity, an even-minded mental state or dispositional tendency toward all experiences/objects, regardless of their affective valence (pleasant/unpleasant/neutral).[33] Several valuable models describe potential psychological and neurobiological mechanisms through which MM could exert its salutary effects.[30,36–45]

Persistent tensions have emerged throughout the MBI movement between (1) adaptation/openness to change versus fidelity/quality/safety, (2) drives for innovation/novelty versus ownership/tradition, and (3) non-attachment to labels versus valuing lineage with respect for teachers. To avoid confusion and to remain inclusive and neutral to these natural tensions, we describe a brief history of the movement—providing context for, and meaning to, various definitions.

Jon Kabat-Zinn began developing the first MBI, *mindfulness-based stress reduction* (MBSR), in 1977, integrating Buddhist insight (Pali: Vipassana) meditation,[46,47] other contemplative practices (e.g., Zen, yoga),[47,48] and modern psychological theories about stress and stress coping for application in health care.[49–52] This work spawned a new secular, mainstream pedagogy for MM training, with a package of practices (i.e., body scan, mindful breathing, sitting meditation, informal mindfulness) bundled in an eight-week program that was designed to cultivate mindful attention in daily life, thereby helping patients to cope with stress, pain, and other chronic conditions. The first adaptation of MBSR, *mindfulness-based cognitive therapy* for depression,[53–56] constituted, along with MBSR, the first generation of MBIs.[57] More than a decade later, these approaches would come to be called *mindfulness-based programs* (MBPs), which have in common the "systematic and sustained training in formal and informal MM practices (for *both* teacher and participants)."[57,58] Crane and colleagues[57] distinguish MBPs from general MBIs, which were adapted from MBSR and mindfulness-based cognitive therapy; although these approaches also focus on cultivating MM practice, they have not always followed the same teacher-training process or other MBP standards. Together MBIs and MBPs focus on MM practice and differ from *mindfulness-informed interventions*,[59] or "third-wave" interventions[60] (e.g., *dialectical behavior therapy* [DBT], *acceptance and commitment therapy* [ACT]),[61,62] which feature mindfulness as a component within a larger suite of techniques and mechanisms of change without an explicit focus on MM practice.[57,59] Research publications on MBIs began increasing exponentially in the 2000s, in parallel with the proliferation of MBIs for specific conditions, and by 2020, MBIs have emerged for many chronic mental and physical illnesses.[21,63,64] Academic mindfulness centers also emerged as dissemination nodes for MBPs,[65] encouraging standards for formal teacher training and teacher competency assessments to ensure program integrity.[66]

This review will focus primarily on the areas with the strongest evidence relating to mindfulness and behavior change. We will describe and expand existing models of *mindful self-regulation* based on neurobiological mechanisms of mindfulness, motivation, and learning.[38,67,68] Then we will review data from meta-analyses and well-designed randomized, controlled trials (RCTs) of MBPs affecting health behaviors. Given the more heterogeneous nature of related interventions (e.g., MBIs, DBT, ACT, *mindful self-compassion*, *integrative mind-body therapy*),[61–63,69,70] we will limit references to these interventions except when MBP research is scarce. It should be noted, however, that DBT and ACT have made a substantial contribution to the understanding of behavior change, with strong meta-analytic evidence for a range of psychiatric disorders—which has contributed to a broader reconceptualization of the mechanisms of behavior change brought about by third-wave cognitive and behavioral therapies.[60,71]

MINDFUL SELF-REGULATION

Self-regulation is the ability to adaptively regulate one's attention, emotions, cognition, and behavior to respond effectively to internal as well as environmental demands.[72–74] Self-regulation impairment is linked to poorer outcomes in school/academics[75,76] and also to poorer physical[77,78] and mental health.[79–84] Self-regulation theory proposes several critical processes for people to initiate and maintain behavior change and to prevent self-regulatory failure,[73] including the capacity for standard setting, motivation to meet standards, self-monitoring, and willpower.[73,74,85,86] We will build on the seminal neuroscience-based frameworks proposed by Hölzel and colleagues[38] and Vago and colleagues,[40] which outlined several relevant synergistic neurocognitive systems that underlie the effects of mindfulness on self-regulation, including *attentional control*, *cognitive control*, *emotion regulation*, and *self-related processes*. Importantly, we

will describe how these self-regulation mechanisms interact with basic neural mechanisms for *motivation and learning*, which are well studied in the addiction and behavioral medicine literature. We will describe how each of these systems may play a role in facilitating the way that MM affects a person's capacity for behavior change (Figure 1). The reviews aim to fill the gap in previous models of mindfulness and self-regulation by describing how, as MM practice develops, it may begin to enhance motivation for change by affecting processes of reward, associative and extinction learning, and habit formation, thereby shifting the balance from unhealthy to healthier behavioral repertoires.

Attention and Cognitive Control

Cognitive control is a fundamental capacity of human cognition that regulates access to specific goal-relevant information to facilitate the performance of specific behaviors.[87–91] *Executive functions* are cognitive processes necessary for initiating and maintaining behavior change, and also for selecting and monitoring behavior toward attainment of goals; *mental set shifting, information updating and monitoring*, and *inhibition* are of particular importance.[92] The subcomponents of cognitive control and executive function include *attentional control/regulation*,[93,94] *cognitive inhibition, inhibitory control, working memory, decision making,* and *cognitive flexibility.*[95] Attentional control can be further subdivided into (1) *volitional orienting* of attention to task-relevant information (e.g., breath, body sensations), (2) *alerting* to and successfully sustaining attention and vigilance for unexpected stimuli, and (3) *conflict monitoring* among task-relevant internal thoughts, feelings, and responses.[96] These attentional processes contribute to recognizing both the consequences of ongoing unhealthy behavior and the affective precursors to avoidance or appetitive behaviors, contributing to adaptive behavior change.

MM may contribute to self-management of clinical symptoms, which are affected by unhealthy behaviors or maladaptive cognitive coping strategies, through explicit cognitive control processes. Two highly cited models[38,40] suggest that mindfulness involves attention regulation (improvement in orienting, alerting/stability, bias, meta-awareness/monitoring)[97–99] and inhibition/switching (decentering, inhibitory control, flexible engagement/disengagement).[100,101] While individual studies support these models,[102] meta-analyses of the effects of mindfulness on behavioral-cognitive assays demonstrate substantial heterogeneity,[103,104] possibly related to diversity in mindfulness techniques, small sample sizes, nonspecific effects of common factors (e.g., group effects, empathic therapists), and multiple strategies for performing behavioral tasks. Moreover, populations with unique cognitive-dysfunction profiles (e.g., substance use, bipolar disorder, depression, age-related cognitive decline, or mild cognitive impairment)[105–110] may experience improvement of disorder-specific dysfunction, whereas healthy participants may be sensitive to ceiling effects. In addition, the mindfulness effect may simply be making the brain more efficient, requiring less effort for a similar result.[106]

Functional neuroimaging research demonstrates that these interrelated cognitive control processes generally engage overlapping higher-order brain networks, including a central executive network, salience network, dorsal and ventral attention networks, and default mode network (DMN).[111] These networks are anchored through a *frontoparietal network* that acts as a flexible hub interconnecting these networks, depending on the contextual and functional demands of cognition.[112–116] This superordinate frontoparietal network, also referred to as the *cognitive control network*, includes the dorsolateral (dl) prefrontal cortex (PFC), posterior parietal cortex, anterior insula cortex, anterior cingulate cortex

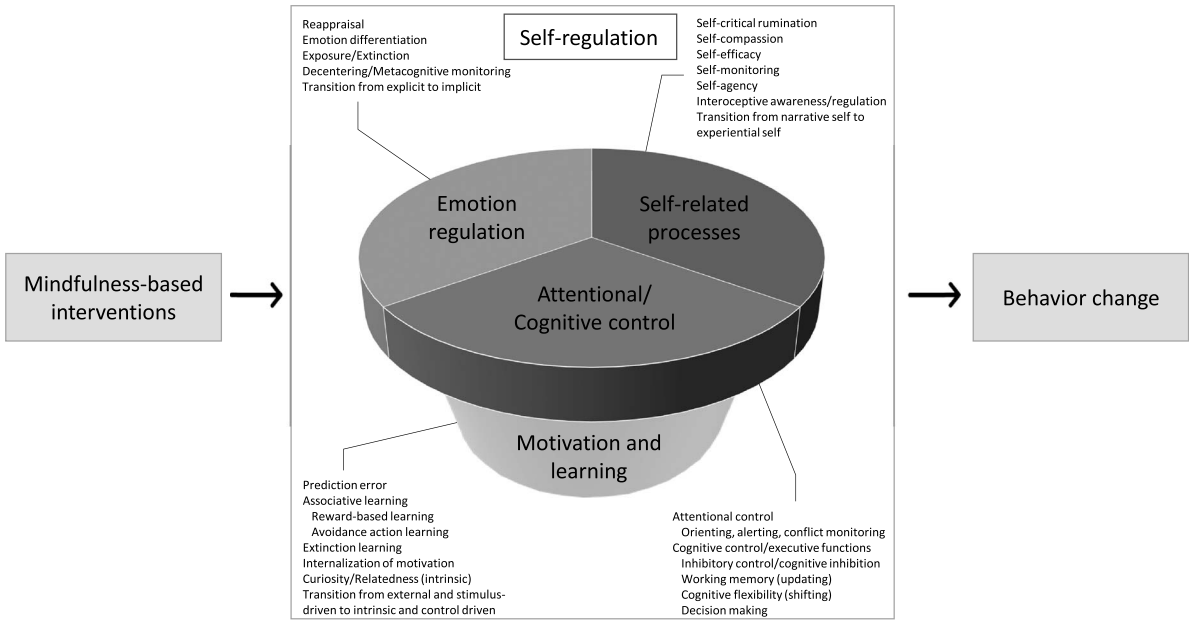

Figure 1. Mindfulness influences on self-regulation and behavior change.

(ACC), and medial PFC.[89–91,113,114] In the context of this flexible-hub framework, growing mechanistic evidence suggests that different types of MM engage associated frontoparietal network brain areas both structurally and functionally, differentially influencing psychological and cognitive outcomes.[117,118] For example, studies show differences in brain activation and connectivity during focused-attention versus open-monitoring meditation,[119] with focused attention engaging attentional control, whereas open-monitoring training engages labeling and emotional nonreactivity.[120] A key aspect of cognitive control is the capacity to monitor for conflicts in information processing and to transmit these signals to other executive functions.[87] This conflict-monitoring capacity has been associated with the ACC and seems to be enhanced with alterations in the ACC in the first few weeks of MM.[121–123] Multiple fMRI studies suggest functional alterations between the ACC and insula in the context of monitoring for aversive stimuli during MM.[123–126] Executive function is negatively affected by hippocampal dysfunction,[127] whereas MBSR has been associated with increases in hippocampal volume,[128] which can affect working memory performance.[129] Inhibitory control is commonly associated with the dorsal ACC (dACC) or inferior frontal gyrus, which may be affected by culture or by developing mental habits of behavioral consistency.[130] In meta-analyses, the dACC is often activated in studies of both focused-attention and open-monitoring meditation.[117]

Given that executive functions are critical for initiating and maintaining health behaviors, MBPs that enhance these processes may affect behavior-change capacity. By enhancing working memory and expanding attentional resources,[131] MM may increase conscious awareness of behaviorally relevant external or internal stimuli (e.g., appetitive cues, stress- or craving-related body sensations), providing more time for higher-order cognitive functions, such as inhibitory control and other executive functions. These changes may help overcome prepotent motor responses, reduce the cognitive effort required for decision making about appetitive health behaviors, and diminish susceptibility to automatic behaviors in response to negative affect.[106,132]

Emotion Regulation

Emotions influence our perception, thinking, and behavior, and are made up of subjective, physiological, and behavioral components.[133] *Emotion regulation* is the ability to modulate emotional experiences, enabling adaptive engagement with internal and external experience, which is essential for well-being and social adaptation.[134,135] A variety of emotion-regulation strategies have been identified, including modifying the situation, altering attention toward it, modifying thoughts about it, and modulating the response to emotional experiences.[136] Effective strategies decrease the subjective experience of negative emotion and its physiological correlates, and are associated with long-term efficacy in daily life.[137] The best-studied strategy is cognitive *reappraisal*, the conscious reinterpretation of a situation in a way that alters its meaning and lessens the emotional impact. Reappraisal may be one of the mechanisms through which MM improves emotion regulation and ameliorates anxiety and depression.[138,139] According to one model with empirical support, mindfulness facilitates reappraisal by interrupting automatic reactions, allowing for conscious reflection.[38,140] With ongoing practice, some theorize that MM practitioners transition from using reappraisal strategies to cultivating states of *nonappraisal* and equanimity, though longitudinal research is needed.[33,38,141] The available evidence also provides some support for *exposure* and *extinction* as key mechanisms for mindfulness-related emotion regulation. Rather than engaging in experiential avoidance[142–144] or thought suppression,[145] MBPs promote the ability to focus awareness on a difficult experience when it arises, creating a condition of exposure to negative emotional reactions.[38,146] This change in focus is often aided by the capacity to shift experiential perspective— to step outside one's immediate subjective experience to a more objective, non-identified awareness of one's experience, which is called *decentering*,[100] *metacognitive monitoring*, or *meta-awareness*.[147,148] With practice, repeated acceptance and awareness of emotional and physiological responses lead to reduction and even extinction of emotional reactivity.[149–151] Therefore, whereas meditation often causes state changes with enhanced autonomic parasympathetic activity, exposure through MM practice may create greater trait *implicit* control over parasympathetic tone, possibly initially through ACC control,[152] and then possibly, with ongoing practice, through ventromedial (vm) PFC modulation of the amygdala.[148,153] Finally, as people learn to be mindful of emotions, the capacity for *emotion differentiation* may be enhanced, which is associated with an enhanced ability for emotion regulation.[154]

Functional neuroimaging research implicates both distinct and overlapping networks involved in different emotion-regulation strategies. *Explicit* cognitive strategies like reappraisal are associated with activation of the frontoparietal executive network involved in selective attention, working memory, and response inhibition, and with deactivation of the amygdala.[155] Neural mechanisms of mindfulness-based emotion regulation appear to differ, depending on the subjects' experience level. Naive subjects given brief training in mindfulness induction for a laboratory study appear to employ top-down control by PFC regions in fashion similar to that of subjects instructed to use cognitive reappraisal.[156] By contrast, for experienced meditators, downregulation of emotional reactivity when in a mindful state appears to involve deactivation of the DMN without deactivation of the amygdala.[157] MBSR completers show decreased amygdala reactivity accompanied by increased amygdala–vmPFC functional coupling, consistent with the finding that symptom improvement in anxiety patients correlates with increased amygdala–vmPFC coupling after MBSR.[153,158] Long-term meditators, in contrast to eight-week MBSR completers, employ implicit emotion-regulation systems involving the insula and vmPFC to modulate emotional reactivity.[153] These findings

suggest that, over time, long-term mindfulness practice promotes greater awareness and acceptance of emotional experience rather than the suppression of emotions by top-down inhibitory control.[148,153,156,157]

Healthy emotion regulation is important for behavior change to modulate emotions in alignment with one's goals.[159,160] Without it, feelings of stress, anxiety, and depression may thwart one's intention to engage in health behaviors related, for example, to diet, exercise, or smoking—which promote positive health outcomes.[161–164] Similarly, for patients with chronic illnesses facing a variety of physical and psychological challenges, emotion regulation is critical for maintaining optimal cognitive functioning and emotional balance.[165] Mindfulness may also improve the chances of successful behavior change by increasing awareness of how emotions influence decisions and behaviors.[137] A recent study of primary care patients with chronic illness reported that an eight-week MBI facilitated emotion regulation and catalyzed health behavior change.[20] Our recent meta-analysis found that subjects receiving MBPs, compared to controls, significantly improved on emotion-regulation measures,[166] suggesting that mindfulness may engage emotion-regulation processes that can improve behavioral outcomes.[67,137,167,168]

Self-Related Processes

Cognitive science describes a continuum of *self-related processes* that aligns closely with large-scale neural networks discovered through functional connectivity studies—networks that are affected by MM.

At one end of the self-related process continuum, the *experiential self* is the self-as-subject, the embodied self that is supported by phenomenological body awareness unextended in time—that is, the sense of "I am in this moment."[169–171] Interoception is the sensory experience of homeostatic afferents related to the body's physiologic state, producing the feeling of present-moment self in the body.[172] Broader definitions of *interoceptive awareness* include the tendency to listen to and trust body sensations as occurring within a dynamic relationship with appraisal and *interoceptive regulation* processes.[173,174] Mindfulness training enhances interoceptive awareness and function.[20] Most MM starts with the body and seems to develop greater interoceptive accuracy.[175,176] Interoceptive dysfunction may lead to difficulties predicting body states and to allostatic dyscontrol.[177] Interoceptive regulation may be enhanced through MM by increasing the capacity for perceptual-inference strategies (i.e., bringing the desired interoceptive state to what is sensed) instead of focusing only on active-inference strategies (i.e., trying to change the experience to the desired state).[178] Numerous recent studies suggest an impact of MM on improving interoceptive measures.[20,179] Meta-analysis and mediation studies are needed to examine the full impact of mindfulness on interoceptive awareness and its effect on behavior change.

Mindfulness neuroscience describes a phenomenological experiential-self network,[171] involving activation of the anterior insula,[40] which is altered after MM training.[180] The insula provides an efficient means for processing large-scale interoceptive information in real time.[181] Interoceptive activity and functional connectivity in the insula is disrupted in depression,[182] which may be associated with a lack of emotional feeling in the body[183] and may be associated with alexithymia.[184,185] Functional connectivity studies of large-scale networks propose a key role of the insula in a salience network, which is posited to shift attention between internal (e.g., internal body sensations) and external stimuli (e.g., external perception) with dorsal attentional and ventral emotional components.[111] Among MM practitioners, the experiential-self network may use moment-to-moment bodily experience in context to establish saliency for attention and regulation of cognitive resources.

At the other end of the self-related process continuum, a *narrative self*[170] emerges during development, starting in late latency,[186] then consolidating during adolescence[187] and emerging adulthood,[188] represented by autobiographical *self-monitoring* and social-cognitive and evaluative functions—in short, the self-as-object, "story of me as a person," temporally extended into the past or future.[170] These cognitive science concepts align with cognitive clinical models of self-related processes, which have an emphasis on self-discrepancy[189] between the actual and idealized narrative self through positive (self-esteem and self-worth[190]) and negative self-evaluation[191,192] (self-devaluation, self-criticism, and self-critical rumination).[74,193,194] Emerging therapeutic approaches also include self-schema[195–197] or multiple self-like parts[198,199] to explain the clinical complexity of narrative self–related processes. The narrative self overlaps with many functions of the DMN, the most prominent large-scale brain network underlying self-related processes.[200] The DMN engages medial cortical regions involved in self-monitoring, self-judgment, self-referential mental activity, episodic-memory retrieval, autobiographical memory, self-related social-cognitive processes, and value-based decision making.[201,202] The DMN connects during adolescent identity formation,[203] increasingly potentiating self-criticism and negative self-evaluative rumination. Among adults, high levels of DMN connectivity are associated with depression.[204] Importantly, DMN activity and connectivity are reduced among experienced mindfulness meditators.[205] In a recent meta-analysis, the posterior cingulate cortex, which is a core DMN node involved in self-related processing,[206] is reliably deactivated during both focused-attention and open-monitoring MM.[118]

Rumination is a response to distress that involves repetitively and passively focusing on symptoms of distress and the possible causes and consequences of these symptoms.[207,208] Rumination predicts depression,[209] bulimia, substance use, self-injurious behaviors, impaired problem solving,[208] and aggressive behaviors.[210] One meta-analysis demonstrated that reductions in rumination partially mediated improved psychological functioning.[151] Another recent meta-analysis found MBPs reduced negative self-related rumination, with a strong effect among six studies with inactive control groups, and potential

for benefit among two studies with active controls.[166] A meta-analysis of brain-imaging studies reports a strong association between DMN core regions, especially the dorsomedial (dm) PFC, and rumination.[211] Reducing negative self-related rumination through MBPs may improve emotion regulation, reducing depressive symptoms and self-criticism. In this way, MM might prevent the detrimental repetition of negative global self-attributions that come when a person has a brief slip of unhealthy behavior after a period of sustained abstinence—which often leads persons to dive into a full-blown relapse, a process that Marlatt[18] named the *abstinence violation effect*.

Other self-related processes on the continuum are the sense of agency[212] related to the experience of one's actions and decision making as an individual agentic self, and *self-efficacy*, which is one's belief in one's ability to succeed in specific situations or accomplish a task.[213] A frontoparietal cognitive control network may provide flexible control in self-related processing[214]—involving coupling between other frontal networks, depending on internally or externally directed task demands.[91,112,114,215] The overarching cognitive control network is therefore recruited to support control of belief and goal-directed strategies, flexibility creating a sense of *self-agency* that contributes to resiliency.[216,217] The dlPFC, which is a core node of the central executive network, is often activated during MM; MM enhances connectivity between the dlPFC and other executive-function regions.[218,219] As MM practice continues over time, the central executive network and other frontal networks may regulate the DMN in control of cognition.[220]

Two small studies have demonstrated increases in task-specific *self-efficacy*, though the increases were not statistically significant compared with controls.[221,222] An uncontrolled, prospective cohort study reported increased chronic illness self-efficacy after eight weeks of MBSR but less self-efficacy at one year.[223] Two larger RCTs of an eight-week MBP with self-efficacy as a secondary outcome reported within-group improvements in self-efficacy (d = 0.3 – 0.43), though this result was not significantly different from a low-dose mindfulness comparator.[20,224] The ability to practice mindfulness may lead to a greater sense of one's ability to make health behavior change; however, it is also possible that initial difficulty attaining expected levels of mindfulness practice may cause an opposite, deleterious effect on global self-efficacy and that the feedback from this failure may affect the capacity to succeed in self-regulation itself.[225,226] Closer analysis of self-efficacy and self-agentic beliefs are needed to understand their role in mindful self-regulation models.

Finally, the warmth with which one relates to one's self is a self-related process that affects self-regulation and behavior. *Self-compassion* involves responding with a warm, kind, and understanding orientation toward oneself, as one would to a close friend, when we suffer, fail, or feel inadequate.[227] Self-compassion may be a mechanism through which MM supports behavior change[228,229] and engagement in health-promoting behaviors[230,231] in the context of diabetes,[232] disordered eating,[233] exercise-related goals in the face of setbacks,[234] and sexual HIV risk behaviors.[235] Self-compassion has been proposed to have a direct effect on self-regulation[236] in part by neurobiologically mimicking a supportive compassionate other, activating the soothing-affiliation system.[237] A meta-analysis demonstrated a strong effect of MBPs for increasing self-compassion in four studies with inactive controls (d = 0.73), though the result was insignificant versus active comparators.[166] A rigorous RCT comparing an eight-week MBP versus a 60-minute mindfulness comparator reported significant effects of mindfulness dose on self-compassion (d = 0.41).[20] MM lowered levels of self-criticism, which was associated with reduced activation in dmPFC nodes of the DMN,[238] initially through dlPFC-mediated self-compassionate reappraisal strategies.[239] Kindness toward self may clarify that one is worthy of being cared about, thereby enhancing motivation for self-care. MBPs focused primarily on attentional aspects of mindfulness in initial manuals/manuscripts, but a beneficial implicit "hidden curriculum" emerged for cultivating warmth and self-kindness.[240] More recently, Kabat-Zinn[241] clarified that "mindfulness" is the same as "heartfulness," acknowledging the importance of love, kindness, and compassion. In this way, mindfulness practice may be described as "warmly being with present moment experience." "Warm" mindfulness infused with self-compassion may be a more effective rapid emotion-regulation strategy than a response of "cool" mindful acceptance alone.[242] Interventions and programs that focus explicitly on cultivating inner compassion, which includes and extends beyond self-kindness, may help facilitate behavior change, particularly for individuals who are prone to excess self-criticism, shame, or unworthiness.[243]

Motivation and Learning

In self-regulation theories, motivation relies on an anticipatory proactive system (i.e., setting standards) and a reactive negative feedback system (i.e., evaluative judgment) for reducing the discrepancy between goals/standards and behavior.[72–74] Early self-regulation theories, based on control theory[72] or homeostasis (feedback error correction),[244] emphasize the role of evaluative judgment to generate motivation for change. Importantly, control of motivation can be *stimulus driven* in response to an external stimulus or *control driven*, which is motivated by, and directed toward, a specific outcome (e.g., intentions, goal setting).[245] The motivation for unhealthy behavior is often driven by external and interoceptive stimuli[246] through *associative learning*—for example, operant conditioning with positive or negative reinforcement. While MBPs may initially engage negative feedback systems utilizing discrepancy through evaluative judgment or predictive error to generate motivation for practice (e.g., "I hate being depressed, so I am motivated to practice mindfulness"), evaluative judgment is deemphasized during MBPs in favor of developing a focus on acceptance, intention setting, and attention toward experiential monitoring rather than self-evaluation.[247–249]

Evaluative judgment and feedback occur at least partially through the phasic activity of midbrain dopamine neurons in the ventral tegmental area that encode a *prediction error* used to guide associative learning throughout the frontal cortex and the basal ganglia.[250] Activity in ventral tegmental area dopaminergic neurons that project to the nucleus accumbens (NAc) may signal that a person's estimate of the value of current and future events is in error, and also indicate the error magnitude.[251] This dopaminergic signaling process for *reward-based learning* begins with the acquisition of a reward after a behavior and leads to operant conditioning (e.g., incentive to repeat a pleasant, rewarding state). This gives way to wanting through incentive salience for cue-elicited behaviors,[252] which causes automaticity and habit formation with the behavior eventually becoming epigenetically encoded in the dorsal striatum,[253–255] making it harder to unlearn.[256]

Aversive learning happens through several mechanisms. *Avoidance action learning*, also referred to as negative reinforcement (e.g., action to avoid an unpleasant negative affect or aversive withdrawal state), depends on dopaminergic signaling in the NAc, though possibly through a different mechanism than approach learning.[246,257] Pavlovian fear conditioning[258] is due to signaling in the basolateral amygdala, which gets transmitted to the central amygdala, leading to the startle/freeze response to a stimulus.[246,259–261] In cases where successful avoidance action takes place, however, a signal from the vmPFC blocks signal transmission to the central amygdala; instead of freezing, there is a predictive error signal in the NAc.[246] Therefore, with aversive experiential learning, the freeze response and fear memory get conditioned first, but then successful avoidance action gets conditioned through engagement from the NAc and vmPFC, priming people to initiate avoidance action when a cue related to the previously aversive stimuli is experienced.[246] Thus, the conditioned action urges that are at the heart of reward and experiential avoidance seem to be encoded in the prediction error in the NAc modulated by the vmPFC, which is the cortical region involved in subjective self-related valuation and self-regulatory goals.[262–264]

Fear memories either get continually reconsolidated after cue exposure or move toward extinction if the feared conditioned effects do not arise through a NMDA receptor–mediated process in the basolateral amygdala.[265,266] *Extinction learning* is the process of inhibiting conditioned fear responses and developing new learning that competes with prior conditioning.[266,267] It also involves prediction error–related vmPFC activity,[268] which may explain why approach and avoidance conditioning often interact when trying to reverse conditioning.[269,270] Therefore, both negative and positive reinforcement approaches may rely on this dopaminergic error-prediction system and modulation from the vmPFC self-related valuation system, which together are likely candidates for the negative feedback evaluative judgment system in self-regulation theory.

New theories based on recent neuroscientific developments also propose that prediction-error processes may be widely distributed throughout the brain's architecture (including the insula) for interoceptive regulation and allostasis, with a key role in emotion and behavioral regulation.[271,272] These neural models of allostasis propose that efficient self-regulation requires *anticipating* needs and preparing to satisfy them *before* they arise through a process of predictive error prevention.[256]

As described above, external rewards and punishments can lead to associative learning through Pavlovian and operant conditioning, and lead to habits that persist with ongoing positive and negative reinforcement. Exposure and associative learning can also be employed both for removing unhealthy habitual behavior and for developing and reinforcing healthy habitual behavior.[41] Mindfulness practice, in particular, is itself a unique healthy behavior that may have the capacity to accelerate the process of extinguishing and replacing unhealthy behavioral repertoires.[273,274] Traditionally, MM has been effectively taught in retreat settings lacking most behavior-activating cues,[46] allowing interoceptive and cognitive exposure with reduced risk for actual harmful behaviors.[275] In community MBPs, however, participants live in high-risk, cue-laden contexts,[276] which can be more challenging. Despite this increased challenge, the social context of the group helps people spend time away from unhealthy behavior-activating cues and in a social environment that values collective learning of mindfulness.[277] As community MBP practice continues, autonomic stability increases,[152] allowing for a "window of tolerance,"[278,279] within which exposure, response prevention, reconsolidation, associative learning, and extinction learning processes[150,280] may begin to unwind the habit learning[273] and fear conditioning[281] that were maintaining unhealthy habits.

At around four weeks of practice, nonclinical MBI participants generally begin to automatically pay attention to the present moment.[282] MM may be utilizing the same neural circuitry and associative-learning mechanisms to establish the habit of mindfulness, which can lead to a process of *therapeutic staged neuroplasticity*.[283] Mindfulness practice associates readily available cues (e.g., the breath, present-moment sensations in the body, the physical experience of stress) with the internal mindful action of warmly being with present-moment experience with constant, accepting awareness of the experience's changing nature—a process traditionally called *Sampajanna* in the Pali language, meaning "clear comprehension of impermanence."[26] This then sets in motion an automatic, internal behavioral repertoire that uses exposure and extinction processes to uproot deeply programmed, unhealthy conditioned behavioral patterns, while developing insight and ability to distinguish which behavioral patterns are healthier and do no harm.[197,274,284] By combining this mindful acceptance with deepening interoceptive awareness, MM then begins to sidestep standard interoceptive feedback processes that drive automatic behaviors, thereby shifting interoceptive regulation toward use of the perceptual-inference instead of active-inference strategies. This change provides

an efficient pathway for discrepancy resolution that reduces predictive errors and refines allostatic regulation.[173,285] The stimulus-driven approach to learning and motivation dissipates as motivation for mindfulness becomes fully internalized and intrinsic motivation for healthy behaviors awakens.

Self-determination theory suggests motivation is derived from competence, relatedness, and autonomy.[286] The motivation for initiating and maintaining behavior change exists on a continuum from amotivation to extrinsic (external pressure), introjected (internal pressure/guilt/shame), identified (feels useful/important), internalized (aligns with deeply held values), and most optimally intrinsic (interesting/enjoyable). Initially, mindfulness and paying attention may come from introjected or identified motivation (e.g., feeling I should meditate or that meditation is important for me). As practice continues and one witnesses the moment-to-moment consequences of unhealthy behaviors and identifies what is deeply valued, motivation for healthy behaviors become increasingly *internalized*, and people become self-motivated.[74] As behavior aligns with internal standards, one develops more proactive systems (e.g., intention setting), reducing the burden from reliance on overreactive, judgment-driven negative feedback systems.[287] Competence and autonomy are enhanced, and intrinsic motivations for wellness are progressively uncovered. *Curiosity*, which is a key aspect of the mindful state,[101] may also modulate midbrain dopaminergic systems.[288,289] Mindfully taking interest in health behaviors and its effects may generate greater levels of *intrinsic motivation*,[287,290] enhancing overall motivational vigor and cognitive control through tonic dopamine release from the ventral tegmental area to the frontal central executive network regions.[291–293] As mindfulness practice proceeds, mindful savoring of healthy, pleasant experiences may restructure reward processes and dopaminergic tone to reinstate value to natural rewards.[294] Negative emotions have specific action urges, while positive emotions tend to broaden and build a person's repertoire of thought-action patterns.[295] Therefore, emotions are often experienced as intrinsic motivation, and emotion differentiation[296] and reappraisal through mindfulness may help reduce emotionally driven unhealthy behaviors and build internalized and intrinsic motivation for healthy behaviors. Finally, kindness and compassion increase *relatedness* with others and potentially make people more sensitive to affiliative motivational systems, through which oxytocin may drive dopaminergic learning and reward in the ventral tegmental area and NAc.[297,298]

Mindful Self-Regulation: Synergy and Integration

Mindful self-regulation integrates attentional/cognitive control, emotion regulation, and self-related processes in synergy with mechanisms for motivation and learning as the practice of MM deepens. Mindful self-regulation starts with attentional control and curiosity about present-moment experience, leading to the development of interoceptive awareness and alternatives to self-critical rumination. Reappraisal of mental content, decentering, and acceptance downregulates autonomic reactivity, allowing for exposure to aversive internal stimuli and ultimately developing equanimity. Yet, for people with high levels of limbic dysregulation (e.g., unresolved trauma, marginalized or disempowered status) or baseline attentional/cognitive impairments, this standard, "cool" MM pathway offers some challenges. In this context, a "warm" MM pathway that starts with establishing safety through a "window of tolerance," while cultivating self-compassion and inner warmth, may be more effective.[299] By reducing self-criticism, autonomic reactivity, and internal conflict, the focus shifts from unhealthy patterns toward self-care.[300] By slowly reducing the limbic load on cognitive control resources, attentional training becomes more accessible and effective. The most effective MM teachers often engage both pathways in tandem, helping practitioners more quickly come into smooth regulation and potentially reducing adverse experiences;[301] yet, this key perspective has not been fully appreciated in previously proposed models of mindful self-regulation. As one begins to pay attention, consistent curiosity and kind awareness allow greater goal-driven control based on values, increased levels of internalized motivation, greater access to intrinsic motivation, and less reliance on stimulus-driven conditioning and evaluative negative feedback systems, eventually unwinding associative learning related to harmful behaviors. Behavior begins to emerge that puts positive cues in the environment, potentially activating healthy behaviors and supporting the behavior of mindful noticing itself, which leads to a positive feedback loop in favor of healthy behavior change. In this way, over time MM may cause an evolution toward greater efficiency in the human self-regulation system within a socio-environmental context, leading to greater feelings of interconnection and relatedness, and ultimately even supporting experiences of self-transcendence.[40]

MBIs' EFFECTS ON PSYCHIATRICALLY RELEVANT BEHAVIOR CHANGE

Substance Use Disorders

Evidence supporting the impact of MBIs for alcohol (AUD) and substance use (SUD) disorders has been growing,[302–310] supporting a few key mechanisms underlying the effect.[41,273,311,312] A meta-analysis of 42 studies in 2017 reported a small effect of MBIs on substance misuse (standardized mean difference = –0.33) and a moderate effect on substance-related craving (standardized mean difference = –0.68).[23] A three-arm RCT enrolled abstinent intensive-outpatient and inpatient residential treatment program completers with SUD (n = 286), comparing mindfulness-based relapse prevention versus relapse prevention versus treatment as usual on substance use outcomes over 12 months. This study demonstrated mindfulness-based relapse prevention had fewer drug use and heavy-drinking days at 12 months compared with relapse prevention alone.[313] Mindfulness-based relapse prevention is the most commonly studied MBI for SUD, while other

MBIs and mindfulness-informed interventions are also being studied for various substances and stages of treatment (e.g., mindfulness-oriented recovery enhancement).[274,314–318] While the strength of evidence for mindfulness effects on certain SUDs during specific stages of treatment is strong (e.g., AUD),[319] evidence for mindfulness and other SUDs is still emerging (e.g., methamphetamine, opioid use disorder).[320–324]

MBI studies for AUD/SUD support the general self-regulation mechanisms above while also focusing on disorder-specific deficits (e.g., reward processing, executive function, cue reactivity). For instance, mindfulness reduces impulsivity among people with opioid use disorder receiving methadone.[197,325] MM may strengthen top-down cognitive control and repair executive-function deficits[326] among people with SUD (e.g., working memory, inhibitory control)[106,326] by increasing ACC/PFC activity and restoring frontostriatal connectivity.[311] Mindfulness practice appears to partially decrease substance use through reductions in craving.[327,328] Craving reduction may be from mindfulness strategies for decentering, acceptance, and attentional control that reduce intrusive cognitive elaboration (i.e., dwelling in positive recollections or attempts to suppress them) and that prevent cascades of emotional and physiologic reactivity.[329] Mindfulness enhances emotion regulation, decoupling depression/negative affect from craving.[327,328,330] MM encourages acceptance, reducing thought suppression,[329] which may reduce craving since the suppression of thoughts/urges often amplifies craving.[331] Mindfulness dampens limbic reactivity and enhances vagal tone,[332] reducing the amplitude and elaboration of physiologic responses to stress and drug cues associated with craving.[333,334] Mindfulness also seems to facilitate physiological recovery (e.g. high-frequency heart rate variability) with faster attentional disengagement after substance-related cues[105,335] and stress.[336] Evidence is also emerging that MM and mindful savoring practice may lead to restructuring reward processing,[273,337] potentially remediating opioid use disorder–related hedonic dysregulation.[338] By exposing practitioners to imaginal and interoceptive substance-related cues during practice and providing rewarding experiences (e.g., feelings of tranquility, curiosity about the novelty of present-moment experience), MM may allow extinction learning and a reversal of operant conditioning, unwinding years of habit formation.[273] Despite the meta-analyses and efficacy and mechanistic studies supporting a role for mindfulness in AUD/SUD treatment, critical issues remain: establishing an evidence base to support real-world implementation in clinical settings; adapting interventions for various levels of care, patient readiness, and stages of treatment; determining the necessary dose of training at each level; and investigating issues of scalability for diverse populations.[305–307]

Eating Behavior/Diet

The efficacy of MBIs on food-related behavior and weight loss has been documented across multiple reviews and meta-analyses.[339–346] Among RCTs, MBIs have large effects on the reduction of binge eating, emotional eating, and eating when not feeling physically hungry,[339,340,344] and moderate effects on the improvement of eating attitudes.[344] Small to moderate effects were noted for weight loss.[339,344,347] MBIs that include both formal and informal practices (e.g., mindful eating)[339] or that are combined with cognitive-behavioral therapy appear particularly beneficial.[341,343]

MBIs may promote enhanced self-regulation and interoceptive regulation through increased ability to notice automatic thoughts or affective cues, accurate appraisal of internal stimuli, or increased awareness of craving, hunger, fullness, and other factors influencing eating patterns.[38,348–350] For example, mindful eating promotes present-moment enjoyment of food while reducing both overall caloric intake and craving-related eating.[351,352] Across studies of individuals who are obese or overweight, MBIs reduced levels of depression and anxiety with medium effect.[344] This improvement in psychological health may disrupt cycles of reactive or emotional eating, foster self-compassion, and improve self-concept.[348,353,354] Overall, MBIs promote healthier behaviors around food and enhance psychological well-being, resulting in weight loss or weight maintenance. More research is needed to examine the efficacy of MBIs on sustained weight loss.

In line with broader research on eating-related behaviors and obesity, MBIs, including mindfulness-based eating awareness training (MB-EAT),[354,355] appear useful for the treatment of binge eating disorder via similar mechanisms of action.[340,356,357] In a meta-analysis, studies of persons with binge eating disorder demonstrated large effects for the reduction of eating pathology, emotional eating, negative affect, and body dissatisfaction, along with a small effect for weight loss.[357] Additional research is needed to compare the efficacy of MBIs to traditional approaches (e.g., cognitive-behavioral therapy) for this pathology.[358] Little is known about MBIs in bulimia nervosa and anorexia nervosa.[356,358–362] Initial meta-analytical reports are favorable, showing reduced eating pathology, emotional eating, and body dissatisfaction with medium effect, as well as weight gain in some underweight participants.[357] Across eating disorders, including binge eating disorder, compassion-focused techniques and mindfulness-informed interventions (e.g., DBT) may be useful.[358,361] Given the unique clinical characteristics of restrictive eating disorders, mindful eating may be distressing for some individuals, especially with acute symptoms. While MBIs show promise, more rigorous research is needed to understand their utility for eating disorder treatment.

Tobacco Smoking

The past decade has seen an evolution of treatments and studies on MBIs for tobacco smoking cessation, with mixed evidence. Two meta-analyses, both of which included four smoking-specific RCTs, found that MBIs were superior to other evidence-based treatments. One reported a moderate effect (d = 0.42),[22] and the other a relative risk of abstinence of 1.88 (1.04–3.40).[363] A 2017 meta-analysis with ten RCTs found that mindfulness-informed interventions (including

brief and mobile interventions) did not differ from comparators.[364] In a now somewhat dated 2015 systematic review, only 13 of 198 articles on mindfulness and smoking were controlled empirical studies, with the majority being pilot or feasibility trials.[365] The first RCT in 2011 compared mindfulness training to cognitive-behavioral therapy (American Lung Association's Freedom from Smoking), in which they found a five-times greater cessation rate with mindfulness,[366] which a secondary analysis demonstrated was moderated by baseline levels of nonjudgment, with less self-judgment of inner experience supporting greater cessation with mindfulness training.[367] Another analysis showed mindfulness training decoupled key links in the smoking reinforcement-learning pathway (craving and smoking).[368] As treatment has moved digital, app-based paradigms have been tested, reporting similar decoupling mechanisms.[369,370] Recent work demonstrated that app-based mindfulness training serves to target DMN brain networks involved in "getting caught up" in craving[206,371] in a dose-dependent manner, with the degree of brain activity reduction in the posterior cingulate cortex predicting smoking reductions, especially among women.[372] More work is needed to replicate and extend findings.

Chronic Disease Self-Management

Self-management of chronic illness[373,374] for common conditions[375] is a priority for improving health care.[376,377] As chronic physical illness is highly comorbid with mental illness,[378] helping patients develop skills to self-manage chronic illness is essential in psychiatry. Chronic illness is often comorbid with anxiety, depression, trauma, and stress.[379–381] Meta-analysis shows small effects for MBIs on enhancing quality of life and reducing anxiety, depression, and stress during chronic illness.[21] Reducing mental health symptoms through MM may support greater chronic disease self-management. For instance, an eight-week MBI—integrated as health care treatment for primary care patients with comorbid mental and physical chronic illnesses—demonstrated increased rates of health-related action-plan initiation compared with participants randomized to a low-dose mindfulness comparator (OR = 2.91).[20] A pilot eight-week MBSR group adapted for hypertension demonstrated significant changes in modifiable determinants of blood pressure—physical activity, diet, and alcohol consumption—for those who were nonadherent to American Heart Association guidelines at baseline, and changes were maintained at one year.[382] Patients with chronic obstructive pulmonary disease who participated in an eight-week group program followed by ten monthly sessions reported increased health behavior changes and improvement in coping with illness.[383] Qualitative findings from 41 individuals with long-term conditions participating in MBSR emphasized that "starting where I am" facilitated changes related to coping with and managing their illnesses.[384] Mindfulness training helped lower blood glucose levels[385] and hemoglobin A1c[386] among those with type 2 diabetes but not among emerging adults with type 1 diabetes,[387] suggesting further research is required.[382] Longer-term continuation groups beyond eight weeks and the addition of kindness and compassion elements may be an important adaptation for helping those living with chronic illness.[388]

Violence, Suicide/Self-Injury, and Other High-Risk Behaviors

Impulsive violence and aggression are critical high-risk behaviors commonly monitored in psychiatry. A systematic review on the effect of mindfulness on aggression and violence included 22 adult studies (4 RCTs), concluding that MBIs and mindfulness-informed interventions (not including DBT) had a significant impact, with effect sizes from 0.21 to 0.87.[389] Mindfulness skills may decrease impulsive thought and aggressive behavior through improved awareness of internal experience, reduction of experiential avoidance, and attentional shifting.[390–392] An RCT with 58 patients with borderline personality disorder found decreased impulsive behavior after DBT versus treatment as usual.[393] An RCT with 101 adults with recent partner aggression comparing ACT versus support group reported ACT was more efficacious in reducing physical and psychological aggression.[394] An RCT with 56 healthy adults comparing MBSR versus waitlist reported MBSR decreased anger suppression and aggressive anger expression.[395] In conclusion, empirical evidence suggests MBIs and mindfulness-informed interventions may reduce impulsive and aggressive behaviors. More methodologically rigorous research and meta-analyses are needed to confirm this hypothesis.

Dispositional mindfulness is negatively associated with suicidal ideation (SI)[396,397] and nonsuicidal self-injury.[398,399] DBT has the most evidence for decreasing suicidal and self-injurious behavior.[400,401] In their systematic review, Chesin and colleagues[402] found six studies of MBIs and suicidal behavior.[403] Four studies reported inferential statistics on the effect of MBIs on SI, with three reporting significant reductions. The study that did not find a significant reduction had relatively low baseline rates of SI, suggesting a possible basement effect.[404] Since that review, other studies have also shown salubrious effects of MBIs on SI,[405,406] with MBIs appearing to uncouple the association between depressive symptoms and SI.[407] MBIs remediate some cognitive factors and self-related processes shown to be risk factors for SI—for example, self-critical rumination, hopelessness, and cognitive reactivity to suicide[408]—but they do not mediate the improvement in SI.[408] Thus, while MBIs may help reduce SI, more needs to be studied regarding potential mechanisms. The strongest evidence for nonsuicidal self-injury has been for DBT, which is effective in reducing nonsuicidal self-injury urges and behaviors in RCTs and meta-analyses, with particularly consistent and strong evidence among adolescents.[401,409,410] Studies of the effects of MBIs on nonsuicidal self-injury have been proposed, but results have not yet been published to our knowledge. One RCT, however, and several open-label trials for ACT show promise.[411,412]

Dispositional mindfulness is positively correlated with inhibitory control and negatively correlated with impulsivity and with compulsive and high-risk sexual behavior.[391,413–420] One RCT with 28 adults comparing 12 individual ACT sessions to a waitlist control condition to evaluate sexual impulsivity related to pornography showed a positive effect of the intervention on compulsive sexual behaviors.[421] Cross-sectional data suggest that mindfulness training could reduce hypersexual behavior.[420,422] Spiritual self-schema therapy, a psychotherapy that includes MM as its primary component, showed increased motivation to reduce HIV risk behavior (i.e., sex without a condom) in an RCT with 72 drug users,[274] and completers of the intervention had decreased impulsiveness on the Barratt Impulsiveness Scale.[197]

DISCUSSION

Limitations of Current MBP Research

Many of the populations who may benefit from health-related behavior change—those with a disproportionate burden and comorbidity of chronic illness, substance use, and high-risk behaviors—are underrepresented in current research on mindfulness and compassion–based programs. These populations include trauma survivors,[423,424] ethno-racial minorities[425,426] (particularly those who identify as African American, Latinx, or indigenous), sexual or gender minorities,[166,427,428] refugee/immigrant populations,[429] and those at the intersection of these marginalized groups.[430] While MBPs may be beneficial for addressing difficulties experienced by these populations (e.g., mindfulness-based relapse prevention may be more effective when delivered within groups composed primarily of ethnic/racial minorities),[431,432] the current research base disproportionately represents well-educated, Caucasian, economically advantaged individuals.[166,425] The paucity of ethno-racial diversity in both MBP researchers[433] and MBP research participants[166,425] mirrors the lack of diversity in psychological and biomedical research.[434]

While the level of MM practice engagement is often predictive of outcomes,[435] trait mindfulness can be measured in the general non-meditating population, where it contributes to self-regulated behavior and positive affect.[436] Moreover, even though eight weeks of MBP group training with a silent day of practice (23 hours in total) was more effective than a one-hour introduction to MM in catalyzing health behavior change, evidence supporting what dose intensity is required for behavior change is not yet definitive.[20,437] Many doorways to discovering mindfulness likely exist, and those that are culturally inclusive of marginalized populations are more likely to be experienced as open doors, supporting greater access.[438] While MBPs are well researched, with reliable dose-related effects within certain demographic groups,[435,439] MBPs as currently designed are unlikely to be the exclusive optimal format for all. Innovations like rolling admissions in mindfulness-based relapse prevention represent an initial step toward accessibility.[440] Overall, demands for the consistency and integrity of MBPs need to be balanced with cultural accessibility in clinical dissemination research.

The future accessibility, relevance, and ethical dissemination of existing MBPs will depend on adequate training of diverse MBP teachers/facilitators and on research agendas that prioritize overlapping areas of cultural humility, cultural accessibility, and trauma-sensitive delivery of MBPs, particularly for those affected by historical and intergenerational traumas.[441] Given the potential relationship between interoception and social power,[442] internalized oppression,[443] and chronic illness,[173,444,445] future research is needed on interventions that cultivate embodiment and interoception,[285] including movement,[446] drumming,[447,448] music,[449–452] and dance[453]—which may be more culturally accessible and specifically helpful for people with intergenerational trauma,[454] and serve to foster social connectedness for marginalized populations with chronic illnesses.[453]

Future Directions: Adverse Effects, Trauma-Informed Training, Dose Effects

Adverse effects have been largely undocumented in the MBP research field. A systematic review of mindfulness-based stress-reduction or cognitive-therapy RCTs reported that only 15.6% of 231 studies included any statement about adverse events.[455] Yet, potential adverse effects may include panic, physical pain, reexperiencing of traumatic memories, and dissociative symptoms.[301] More needs to be understood about how program, participant, and teacher/leader factors contribute to adverse events.[456] Britton[457] and Grant and Schwartz[458] propose a research agenda that takes into account that unwanted effects may emerge when aspects of mindfulness, such as decentering, focus on body sensations, and present-moment focus, are overemphasized. As the forms of adverse effects and reactions to symptoms vary based on individual and context, teachers and leaders should train in how to best monitor for, and respond to, adverse effects in MBP research.[459,460]

Program design and training must be sensitive to potential adverse effects experienced by trauma survivors. A majority of individuals will experience a traumatic life event, and a subset of these will develop posttraumatic stress disorder (PTSD).[461] During MBPs, trauma survivors may be more likely to experience certain adverse effects such as traumatic flashbacks[301] and dissociation.[462] Trauma-informed training assumes that everyone might have a trauma history and focuses on offering choice, de-shaming adverse effects, supporting individual agency, and responding skillfully to trauma-related effects when they arise.[424,460] MBPs have the potential to substantially reduce PTSD symptomology and to support neurobiological changes in networks implicated in PTSD psychopathology.[111,463–469] Future research is needed on interventions that incorporate self-compassion, as it may mitigate and transform the shame-based nature of PTSD.[470] When patients with PTSD are immersed within a safe, validating, healing community, such as well-designed trauma-informed

MBP groups featuring self-compassion, they are likely to successfully initiate meaningful behavior changes.[20]

Finally, future clinical trials should include validated assays in clinical settings measuring the impact of dose effects on the self-regulation components described herein, and the extent to which each component mediates health behavior change.[471] More dismantling and dose-response studies could help clarify the most active components and their individual contributions.[120,472] Care should be taken with this investigative approach, however, since it carries risks of oversimplifying MBPs to just a collection of techniques in a toolbox.[473] When mindfulness programs are offered solely from this instrumental dimension of a skill to be acquired,[241] then the synergistic, holistic, and seemingly paradoxical approach to cultivating mindfulness, which many patients experience as engaging and deeply healing in MBPs, may be unwittingly sacrificed.

CONCLUSION

A growing evidence base supports the benefits of mindfulness for behavior change. A mindful self-regulation model based on an integration of neuroscientific findings describes the complex and synergistic effects of attention/cognitive control, emotion regulation, and self-related processes, as well as motivation and learning mechanisms that may provide a unique pathway toward sustainable behavior change. While evidence supports the impact of mindfulness on behavior change for key health behaviors related to psychiatric practice, more high-quality research is needed, especially with objective measures, larger samples, replication studies, active controls, and formal monitoring of adverse events.[474] The field will also benefit from additional research on the impact of integrating compassion practices and from a focus on trauma-sensitive adaptations for diverse populations.

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