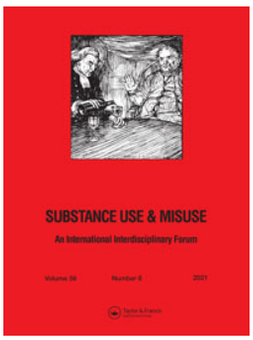

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ORIGINAL ARTICLE

An Integrated Model of Nature and Nurture Factors that Contribute to Addiction and Recovery

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ABSTRACT

Background: In the context of the opioid epidemic and growing awareness of addiction as a public health concern, there are efforts to inform the public, patients, families, and policy makers about the factors that contribute to addiction and facilitate recovery. Several theoretical models provide useful frameworks for this discussion, but each of them has limitations. *Objectives*: This paper presents an accessible yet comprehensive theoretical model that integrates empirical evidence about addiction etiology and recovery using the nature-nurture paradigm. *Results*: The model presents substance use along a continuum, and identifies risk and protective factors in multiple domains that have been identified by research. The domains on the nature side of the model include genetic and biological factors, comorbid psychiatric and medical disorders, physiological reinforcement of substance use, and changes to neural mechanisms. The domains on the nurture side of the model include sociocultural factors, environmental factors, personality, emotions, cognitions, psychological reinforcement of substance use, and cognitive and behavioral changes. The progression from increased or decreased substance use to addiction or recovery is mediated by changes in neural mechanisms and cognitive and behavioral changes, which have feedback loops with the physiological and psychological reinforcement. *Conclusions/Importance*: This model is a useful heuristic, consistent with a public health framework, for discussing addiction and recovery with patients, their families, and the public. This integrated model of nature and nurture factors has the potential to inform clinical practice, consultation, research, prevention programs, educational programs, and public policy.

KEYWORDS

Addiction; substance use disorder; etiology; recovery; comorbidity; theoretical model

Nearly 120 years after the first international efforts to reduce opium use (Hanes & Sanello, 2004), communities are still struggling to understand substance use patterns and ways to reduce the negative effects of addiction. The opioid epidemic has increased attention to substance use disorders (SUD), and more of the general public is trying to understand factors that contribute to addiction and facilitate recovery. In 2018, 20.3 million Americans, 7.4% of the population age 12 or older, met diagnostic criteria for a past year SUD, and nearly 10% of American adults will meet diagnostic criteria for one or more SUD at some point in their lifetime (Substance Abuse & Mental Health Services Administration, 2019). The majority of people who develop SUD will recover, either on their own, with social support programs, or with professional treatment (Abt Associates & Hart Research Associates, 2010; Sobell et al., 2000), and more than 25 million individuals are in remission from a previous SUD (White, 2012).

With rising rates of overdose deaths, and SUD gaining more media exposure, there is increased effort to address SUD in a public health framework and to develop policies that could reduce the prevalence of SUD and related problems. Researchers and clinicians have been guided by multiple theoretical models of addiction that focus on various factors that influence addictive behaviors and recovery processes, however, each of the models has limitations. This paper presents an accessible yet comprehensive integrated theoretical model of *nature* and *nurture* factors that impact the development of SUD and recovery processes, and this integrated model provides a useful framework for education, prevention, treatment, research, and policy development.

Extant models of addiction typically include components of disease models and/or psychosocial models of addiction, but the proposed model provides a higher level of detail about factors associated with addiction and recovery. The term addiction is used in this model because it has applicability for behavioral addictions as well as SUD, but the primary focus of this paper is to present evidence that supports this model as a framework for understanding SUD development and recovery pathways. For each domain, risk factors are identified to help understand addiction etiology and relapse, and protective factors are identified to help understand ways that prevention and treatment programs can promote resilience to addiction development and recovery from addiction.

Overview of addiction etiology models

One of the earliest, and perhaps most influential, models of addiction was the Jellinek Curve, which illustrated experiences common for individuals during addiction and recovery

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using a disease model paradigm (Hazelden Betty Ford Foundation, 2016; Jellinek, 1960). The Jellinek Curve represents stages of addiction development (*initial, crucial, chronic*) preceding a "rock bottom" loop of obsessive and detrimental substance use, which then can lead to improvement phases of *rehabilitation* and *recovery*. The *crucial* and *chronic* phases of addiction development include symptoms such as grandiose behavior, feelings of guilt, avoiding family and friends, unreasonable resentments, physical deterioration, moral deterioration, impaired thinking, and vague spiritual desires. The *rehabilitation* and *recovery* phases include processes such as learning that addiction is an illness, having an honest desire for help, experiencing the return of self-esteem, establishing a new circle of stable friends, experiencing the rebirth of ideals, and recognizing rationalizations. The Jellinek Curve continues to be an influential model for 12-step treatment programs and support communities, and it has been a driving force in the public perspective that "rock bottom" is a necessary step prior to entering recovery. While this model demonstrates the progressive nature of addiction development and recovery pathways, it proposes that people will follow a similar predictable path in both addiction and recovery. This is inconsistent with research that has indicated that there are many pathways to recovery (Abt Associates & Hart Research Associates, 2010), and many individuals recover from SUD without experiencing the processes delineated along the Jellinek Curve. Additionally, the Jellinek Curve places emphasis on intrapersonal factors (e.g. character flaws, choices) to the near exclusion of biological, sociocultural, and environmental factors.

The National Institute on Drug Abuse (NIDA) model of addiction is a more contemporary disease model that frames addiction as a brain disease (National Institute on Drug Abuse (NIDA), 2014). Unlike the Jellinek Curve, it demonstrates the interactions between biological risk factors (i.e. genetics, biological sex, mental disorders) and environmental risk factors (i.e. peer influences, home and school environments, cost and availability) for addiction, and it highlights the importance of brain mechanisms in the development and maintenance of addiction. However, the NIDA model has somewhat limited exploration of the intrapersonal, social, behavioral, and cultural factors involved in the addiction development and recovery. This limitation has the potential to promote policies and perspectives that minimize the impact of social and cultural factors, which in turn could perpetuate social inequities that have significantly impacted minority communities (Hart, 2017).

Marlatt's cognitive-behavioral model of relapse prevention has been influential for addiction treatment since it provides more detail about the psychosocial processes that impact substance use and recovery (Larimer et al., 1999). This model highlights the importance of high-risk situations, coping responses, self-efficacy, and the abstinence violation effect for individuals trying to abstain or control substance use. This model identifies skills that are related to the relapse and recovery processes (e.g. urge management, avoidance strategies, self-monitoring, cognitive-restructuring), and therefore it has strong clinical utility. However, this model neglects the genetic and biological components that impact addiction and recovery, and it does not fully identify environmental or sociocultural domains that could be addressed in prevention and policy efforts.

Other models that have influenced our understanding of addiction etiology and recovery include models that focus on the impact of stress on the development of addiction (Khantzian, 1987; Zubin & Spring, 1977; Zuckerman & Riskind 2000). The self-medication model presents substance use as an active coping skill intended to modulate the impact of an underlying psychological or physical ailment (Khantzian, 1987). The stress vulnerability model identifies stress as the key risk factor for developing SUD or other maladaptive coping strategies (Zubin & Spring, 1977). The diathesis-stress model posits that stress triggers an existing underlying vulnerability to SUD (Zuckerman & Riskind 2000). Each of these models identifies the global impact of stress as a primary factor contributing to the development of SUD. However, these models do not sufficiently demonstrate the influences of other psychological factors, nor does it sufficiently address biological, social, and cultural factors.

This paper presents a theoretical model that integrates *nature* and *nurture* factors that contribute to the development of addiction as well as facilitate the recovery process (see Figure 1). The nature-nurture framework is a useful heuristic since it is well known in the general population, and using this common nomenclature could stimulate discussions with patients and families while also providing sufficient detail to inform decision making by clinicians, researchers, educators, and policy makers. This model is intended to be comprehensive, and thus lacks parsimony. It therefore offers greatest potential to conceptualization and program development rather than quantitative evaluation of etiology of addiction and recovery. The model incorporates research findings about the underlying mechanisms and also provides nuanced representation of substance use along a continuum. For each domain, research evidence is presented, and examples of risk and protective factors are provided.

Overview of the integrated model

This integrated model (Figure 1) presents substance use along a continuum from initial use to increased or decreased use to addiction or recovery. A social trigger is indicated as the starting point, since social factors nearly always precipitate decisions to use a substance for the first time. The model demonstrates that the progression from initial substance use to either increased or decreased substance use is mediated by the physiological and psychological reinforcement produced by the substance. The model shows that physiological reinforcement is influenced by genetic and biological factors as well as psychiatric and medical comorbidities, whereas psychological reinforcement is influenced by sociocultural, environmental, emotional, cognitive, and personality factors. The progression from increased substance use to addiction, or decreased use to recovery, is mediated by changes in neural mechanisms and cognitive and behavioral changes. Modifications in neural mechanisms

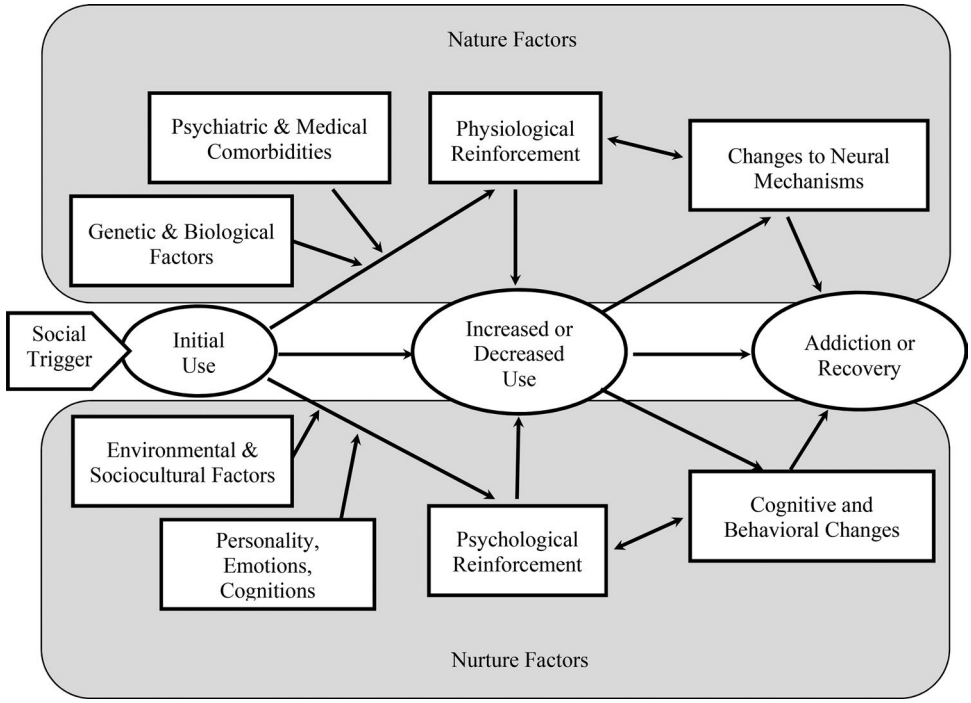

Figure 1. An integrated model of nature and nurture factors that contribute to addiction and recovery.

are part of a feedback loop with physiological reinforcement, and adjustments in cognitions and behaviors are part of a feedback loop with psychological reinforcement.

Nature factors impacting addiction

Physiological reinforcement

Physiological drug effects include pleasant and unpleasant changes in the user's body, and these effects can be considered the nature-based reinforcers that shape substance use behaviors through positive reinforcement, negative reinforcement, or punishment. These physiological reinforcers, including intoxication symptoms and relief of negative physical states, are substance-specific, and are driven by the biological impact that a substance has on a person's physiological and neurological functioning. These physiological effects are caused by the influence of a psychoactive substance on neurotransmission and physiology. Common physiological reinforcers that operate through positive reinforcement (making something better) include increased energy, increased pain tolerance, sleep induction, quicker reaction time, increased alertness, and pleasant bodily sensations. Common physiological reinforcers that operate through negative reinforcement (reducing something unpleasant) include pain relief, reduced muscle tension, and reduction of other unpleasant bodily sensations. Common physiological reinforcers that operate through punishment (inducing something unpleasant) include unpleasant bodily sensations like racing heartrate, elevated blood pressure, decreased respiration potentially to the point of suffocation, unpleasant changes in body temperature, increased muscle tension, nausea, vomiting, and symptoms of overdose.

These physiological reinforcements influence whether a person is more or less likely to use a substance again (Stewart et al., 1984, Young et al., 2004), and the strength of these physiological reinforcements is influenced by genetic factors, biological factors, and comorbid psychiatric and medical disorders (Goldstein & Volkow, 2002).

Genetic and biological factors

A great deal of research supports genetic influences on SUD. With a heritability factor of .54, genetic vulnerability accounts for about half of an individual's risk for developing a SUD (National Institute on Drug Abuse (NIDA), 2016), which makes individuals 10 times more likely to develop a SUD if they have a first degree relative with a SUD. Research suggests that genetically-based individual differences in neurochemistry and corresponding neural structures impact vulnerability to addiction (Prom-Wormley et al., 2017; Riggs & Greenberg, 2009; Sinha, 2011), likely due to the effects of those differences on the saliency of substance effects. Each person's brain is different – the symmetry, density, and number of synapses vary from person to person, and these differences could impact how an individual processes and reacts to psychoactive substances (Arbuthnott & Wickens, 2007). Neurophysiological research suggests that dopamine receptor density may be a genetically determined factor that impacts vulnerability to SUD – individuals with fewer dopamine receptors are likely to experience the physiological rewards of a substance more strongly than those with sufficient dopamine receptors (Schultz, 1998). In particular, dopamine receptor D2 deficiency has been linked to increased rates of SUD and the concept of the 'reward deficiency syndrome', which describes the interaction

between addictive, impulsive, and compulsive behaviors (Blum et al., 1996; Mallard et al., 2016; Young et al., 2004).

In addition to the overall genetic vulnerability, research suggests that certain genetic markers are implicated in SUD, such as the ALDH1 deficiency being linked to a flushing sensation in response to alcohol use. Since the ALDH1 deficiency is more common in Pan-Asian individuals, that particular genetic protective factor is related to a biological factor, and individuals with that gene are less likely to use alcohol heavily because the physiological response is less pleasant (Chen & Yeh, 1989; Gilder et al., 1993). Biological sex is another biological factor that impacts alcohol metabolism and thus risk for alcohol use disorder; females metabolize alcohol less efficiently than males, leading to stronger physiological responses to alcohol (Baraona et al., 2001). Stress responsivity through the hypothalamic-pituitary-adrenal (HPA) axis, either activation or suppression, has been shown to influence the continuation of certain SUD (Sloboda et al., 2012). Additionally, HPA axis alteration contributes to later relapse potential, driven by metabolic protein changes, or genetic expression (Kreek et al., 2005; Sloboda et al., 2012). The stronger physiological response could lead to more unpleasant experiences, which seems to confer a level of protection to females, who are both less likely to engage in heavy drinking and less likely to be diagnosed with an alcohol use disorder than males. Age at first substance use is also a critical biological factor in the physiological response to substance use; adolescents are more vulnerable to the neural impact of substances, and thus adolescent onset of substance use is associated with higher rates of SUD later in life (Chen et al., 2009; Isaksson et al., 2020; Jordan & Andersen, 2017; Riggs & Greenberg, 2009). Beyond biological sex and age of onset, there is evidence that prenatal alcohol exposure could increase the risk of the child developing a SUD in their lifetime (Alati et al., 2006; Baer et al., 2003; Famy et al., 1998).

These examples are a few of the ways that genetic and biological factors impact the development of addiction, primarily by moderating the saliency of the physiological reinforcement of substance use, and Table 1 includes a list of risk and protective factors in this and other domains.

Psychiatric and medical comorbidities

Comorbidity plays a large role in vulnerability to SUD and the likelihood of recovery (Kessler et al., 2005; Kreek et al., 2005; National Institute on Drug Abuse (NIDA), 2014; Wang et al., 2005). Both medical and psychiatric disorders are related to increased risk of SUD, and both patterns of comorbidity could complicate recovery. There is substantial evidence that chronic pain, traumatic brain injury, and psychological disorders increase risk for SUD (Giordano & Schatman, 2008; Taylor et al., 2003; Cassano et al., 1998), and psychiatric disorders are highly comorbid with SUD (Kessler, Chiu, et al. 2005; Kessler, Berglund, et al. 2005). Comorbidity is a driving force in the saliency of physiological reinforcements; those with comorbidities are likely to experience the physiological effects of psychoactive substances more strongly, and this increased saliency has neurological underpinnings. Meta-analytic findings indicate that children with ADHD are significantly more likely to develop SUD than children without ADHD (Lee et al., 2011; Tarter et al., 2007), and recent research suggests that ADHD and SUD share primary neurotransmitter systems, which influence communication frequencies of dopamine, norepinephrine, and serotonin transporter reuptake inhibition (Young et al., 2015). Development of PTSD also is linked to increased rates of SUD (Brady & Sinha, 2005), potentially due to the over-activation of the amygdala for both conditions and similar patterns of neurobiological disturbances (Enman, Zhang, & Unterwald, 2014).

For individuals with comorbid medical or psychiatric disorders, the impact of the physiological reinforcement of a substance is likely to be more powerful (Lessov et al., 2004). The self-medication hypothesis has substantial support, and demonstrates the propensity for individuals to use substances as a way of moderating medical or mental distress (Khantzian, 1987). Risk and protective factors in this domain are presented in Table 1.

Changes in neural mechanisms

Beyond innate differences in neurochemistry and neuroanatomy, a substantial body of research indicates that prolonged substance use can lead to changes in brain functioning and brain structure (Koob & Volkow, 2010). The majority of individuals who use substances do not develop a SUD, and research suggests that changes in neural mechanisms are a critical determining factor in whether someone who uses substances will become addicted or not. Additionally, early exposure to substances has been shown to increase the risk of an individual's susceptibility to chronic problematic substance use due in part to the neuroplasticity during critical periods of brain development (Tarter et al., 2003; Zullino & Khazaal, 2008). Specifically, the prefrontal cortex is not fully developed until later in life, thus early exposure to psychoactive substances has the potential to alter the brain more dramatically than exposure later in life (Goldstein & Volkow, 2002; Riggs & Greenberg, 2009). As drug use continues, postsynaptic changes occur to neurons in the brain, which then alter the density of dendritic spines in the nucleus accumbens and the prefrontal cortex (Robinson & Kolb, 2004). But even delayed exposure to substances has the potential to produce structural and functional changes in the brain.

This integrated model illustrates that one way that these neural changes impact the development of addiction is through a feedback loop between the changes in neural mechanisms and the intensity of the physiological reinforcement – when substance-related brain changes occur, then the power of the reinforcements change as well. For example, chronic morphine consumption decreases the size of dopamine neurons, and alters protein expression. This neural morphology could potentially reflect an overall decrease in dopaminergic transmission to the nucleus accumbens (NAc) from the ventral tegmental area (VTA), a location where

Table 1. Risk and protective factors that contribute to addiction and recovery.

	Domain	Risk Factors or Characteristics	Protective Factors or Characteristics
Nature Factors	Genetic and Biological Factors	Genetic family history of SUD Dopamine receptor deficiency Adolescent onset of substance use Biologically male Prenatal alcohol exposure	Biologically female Post-adolescent onset of substance use Being of Asian descent due to the increased likelihood of ALDH1 deficiency Having a sufficient innate density of dopamine receptors
	Psychiatric & Medical Comorbidities	Chronic pain Significant medical problems Traumatic brain injury Psychotic disorders Mood disorders Anxiety disorders ADHD High functioning Autism	Being healthy Neuro-typical prefrontal cortex control High tolerance to pain
Nurture Factors	Environmental & Sociocultural Factors	High availability of substances Overt use or sale of substances in the community Highly restrictive alcohol and drug policies Exposure to substance-related media and marketing peer substance use Exposure to trauma High stress environment Homelessness, housing instability, or housing insecurity Food insecurity History of abuse or neglect High family conflict Being single, divorced or separated High interpersonal distress Limited social network Being unemployed or retired Low or high socioeconomic status Being White/Caucasians, American Indians, or Alaska Natives Full-time college student Lesbian/bisexual woman Gay/bisexual man Age groups 18-25 or over 65	Effective drug education and prevention efforts Opportunities for a healthy lifestyle Availability of alternate social activities Availability of affordable healthcare Gainful employment opportunities Sufficient access to social service support programs Access to after school programs Involvement in sports or social clubs Positive role models Neighborhood safety and stability Non-prohibition policies Higher taxation on substances Marketing restrictions Financial stability Appropriate parental engagement Recognition for positive behavior and achievements Family bonding Strong social support Higher education Age group 26 – 65 Having children Being married
	Personality, Emotions, Cognitions	Extraversion Neuroticism Sensation seeking Impulsivity Conduct Disorder Antisocial Personality Disorder Borderline Personality Disorder	Conscientiousness Cautiousness Dutifulness Perfectionism

dopamine neurons are primarily produced (Choa & Nestler, 2004). Tolerance and withdrawal are the primary manifestations of these feedback loops; as structural and functional neuronal changes occur, more of the substance is needed to achieve the desired effect or maintain homeostasis. As tolerance and withdrawal build, the brain becomes desensitized to the substance effects, the person experiences stronger cravings for the substance, and the saliency of the physiological reinforcement grows stronger as addiction progresses. As addiction develops, the physiological reinforcement will typically progress from noticeable pleasant effects, to diminished pleasant effects, to feeling "normal" only when under the influence of the substance, to reliance on the substance to relieve unpleasant withdrawal symptoms. Koob (2014) coined the term, "anti-reward" to better explain dopaminergic system alterations after chronic drug usage; this "anti-reward" system initiates the reverse of dopamine release through modification of dynorphin, an endogenous opioid, which ultimately inhibits natural dopamine release overtime. Furthermore, this "anti-reward" system is not exactly the manifestation of physical signs of withdrawal symptoms, but is correlated more with the motivational signs of withdrawal. Variations and alterations resulting from continual usage of psychoactive substances can alter mRNA degradation, which can translate to a dopamine variant, D2 or DRD2, eventually changing the overall functionality in neural pathways (Kreek et al., 2005; Lawford et al., 2006). In recovery, the changes in neural mechanisms can be addressed by appropriate pharmacotherapies and through abstinence that give the brain a chance to partially recover from physiological dependencies. Specific medications that target the regulation of neurotransmission have been shown to reduce the impact of physiological reinforcement of substances, reduce the experiences of cravings, and help the brain rebalance the neurotransmitter systems (Kreek, LaForge, & Butelman, 2002; O'Brien, 1997).

Nurture factors impacting addiction

Psychological reinforcement

Psychological substance use experiences are more subjective than the physiological effects of the substance and are

influenced by non-biological factors, which can operate through positive reinforcement, negative reinforcement, or punishment. These subjective experiences include pleasant and unpleasant changes in emotional, social, perceptual, or cognitive states, and are the nurture-based reinforcers that shape substance use behaviors (American Psychiatric Association, 2013; Spanagel, 2011). Common psychological reinforcers that operate through positive reinforcement (making something better) include increased pleasant emotions, elevated mood, increased energy levels, increased motivation, increased sociability, improved sense of self-confidence, enhanced feelings of intimacy, novel pleasant perceptual experiences, and altered but pleasant thought processes (Bigelow, Brooner, & Silverman, 1998; de Wit & Phan, 2010; Spanagel, 2011). Common psychological reinforcers that operate through negative reinforcement (relieving something unpleasant) include relief of negative emotional states and moods, relief of fatigue, and suppression of unpleasant thoughts and insecurities. Psychological reinforcers that operate through punishment (inducing something negative) would include things like increased anxiety or depression, increased risk taking, paranoia, unpleasant hallucinations/delusions, negative impact on self-esteem, and insomnia. These psychological reinforcers influence whether a person is more or less likely to use a substance, and the strength of psychological reinforcement of substance use is influenced by environmental, social, cultural, emotional, cognitive, and personality factors (Sloboda et al., 2012; Tsavou & Petkari, 2020).

Environmental, social, and cultural factors

Environmental factors that influence substance use behaviors and the saliency of psychological reinforcement include ease of access to the substance, media messages about the substance, exposure to marketing and prevention initiatives, overt substance use in the community, alcohol and drug policies, exposure to stress and trauma, availability of alternative activities, opportunities for a healthy lifestyle, and access to social service supports (Haller & Chassin, 2014; Kadushin et al., 1998; Kuerbis et al., 2014; Lo & Cheng, 2011; Nunez-Smith et al., 2010). For example, research indicates that greater media exposure is associated with elevated use of tobacco, illicit drugs, and alcohol among children and adolescents (Nunez-Smith et al., 2010). Studies show a dose-response relationship between music that references cannabis and increased cannabis use among adolescents who were exposed to this content for 3 or more hours a day (Primack et al., 2009). Furthermore, those who have experienced adversity during early to mid-childhood and/or adolescence (i.e. abuse, neglect, separation or loss) have a higher risk of substance use or poorer health in late adolescence and early adulthood (Keyser-Marcus et al., 2015; Yoon et al., 2020). Exposure to stressful living situations and trauma increase the likelihood of developing SUD, with studies indicating nearly half (49.3%) of patients recovering from SUD have experienced physical or sexual trauma in their lifetime (Keyser-Marcus et al., 2015). Exposure to impoverished neighborhoods is associated with greater substance use, higher stress, and lower perceived safety in adolescents (Mennis et al., 2016). However, access to after school programs, involvement in sports or social clubs, having positive role models, and neighborhood stability are environmental protective factors against the development of SUD (American Institutes for Research, 2008; Thorlindsson, Thorolfur, Bernburg, & Gunnar, 2006). Availability of healthcare and sufficient access to employment and social service support are protective as well. Additionally, there is evidence that non-prohibition policies, higher taxation on substances, marketing restrictions, and exposure to effective prevention efforts are related to lower rates of SUD (Stockings et al., 2016).

Social and cultural factors that influence substance use include social norms, social consequences of use, cultural traditions and belief systems, and the environment in which people are born, live, work, and learn (Singh et al., 2017; Unger et al., 2004). Social determinants of health, such as race/ethnicity, education, income, poverty, unemployment, housing, and geographic location, have major contributions to each individual's physiological and psychological well-being, quality-of-life, and risk and protective factors. A long-term trend analysis for the United States from 1935 to 2016 shows persistent social disparities and health inequalities among racial/ethnic, socioeconomic, and geographic factors (Singh et al., 2017). Epidemiological data generally indicates that White/Caucasian groups use substances at rates equal to or higher than other races or ethnic groups (Center for Behavioral Health Statistics and Quality, 2017), yet there are subcultural factors that increase risk for SUD in minority populations.

The minority stress model developed for sexual minority groups (Meyer, 2003) has implications for other minority groups as well, and the model posits that members of marginalized groups experience higher levels of stress due to their chronic exposure to discrimination, and that perpetual stress in turn elevates risk for mental health and substance use problems. For minority and marginalized populations, significant correlations between racism and/or discrimination and substance abuse have been observed in employment, education, and healthcare settings (Forest-Bank & Cuellar, 2018; Sanders-Phillips et al., 2014). Workplace discrimination among Mexican-origin immigrants exhibited high risk alcohol abuse and dependence rates (Myers, 2013). Among African American high school students (grades 9-12), perceived racism was correlated with higher rates of depression and post-traumatic stress disorder (PTSD). In turn, depressive symptoms and PTSD were associated with the more proximal effect of increased alcohol and marijuana use (Sanders-Phillips et al., 2014). Swift and colleagues (2019) found that, when discrimination is controlled for, black persons would be at a 45% lower risk of reporting opioid pain reliever misuse when compared to white counterparts, thus indicating race is a risk factor for prescription opioid misuse due to the impact of discrimination experiences. Furthermore, studies show that gender- and sexuality-based harassment is independently associated with greater

substance use among middle and high school students (Coulter et al., 2018). Among adults, lesbian and bisexual women have higher rates of alcohol use disorders than heterosexual women, and gay and bisexual men have higher rates of drug use disorders than heterosexual men (Kerr et al., 2015; Green, Bux, & Feinstein, 2013; Green & Feinstein, 2012). Additionally, Connolly & Gilchrist (2020) found that there is a higher prevalence of substance use among the transgender population compared to their cisgender counterparts.

Discriminatory microaggressions are characterized by subtle and persistent verbal, behavioral, and environmental insults, made consciously or subconsciously, that perpetuate negative connotations to a person or group (Sue et al., 2007). Experiencing microaggressions has been found to influence hormonal cortisol reactivity through encouraging over-activation of the HPA axis related to the "fight or flight" responses (Majeno, 2016). Excessive HPA axis activation and elevated cortisol have been linked to chronic medical conditions (Chrousos, 2009) as well as increased risk for substance abuse and relapse (Milivojevic & Sinha, 2018).

Beyond the impact of minority stress, specific cultural traditions also impact substance use behaviors. Native American groups have cultural traditions that include use of psychoactive substances for spiritual practices and for coping with the stressors of acculturation (Prince, O'Donnell, Stanley, Swaim, 2019). Additionally, subcultures that are linked to casinos have elevated drinking rates (Preston, 2009). Among Hispanic/Latinx subcultures, adolescents who identified as "Cholo/a" or "La Raza" in Los Angeles, CA have shown evidence of an increased risk of substance use by the 11th grade (Unger et al., 2014). Peer group influences play a strong role in adolescent substance use behavior. The effects of peer drinking behavior/patterns on an individual's drinking behavior are significant, with stronger associations as the adolescent becomes more involved in the party subculture (Thorlindsson & Bernburg, 2006). Greater spirituality, but not religious affiliation, has demonstrated association with decreased rates of substance use (Bakken et al., 2014; Tonigan et al., 2013).

Family dynamics and perceived parental support also have an impact on an individual's substance use (Measelle et al., 2006). Rogers et al. (2018) found parental emotional maltreatment was correlated with a child's substance use. Furthermore, the severity of neglect within the first four years of life predicts the development of internalizing symptoms, which in turn are related to substance use at age 16 (Duprey et al., 2017). Some research suggests that fearful and avoidant attachment styles appear to be common among those with SUD, suggesting importance of early childhood attachment to SUD development (Owens et al., 2014; Schindler et al., 2005). Additionally there are correlations between divorce rates and substance use (Collins, Ellickson, & Klein, 2007; Caces, Harford, Williams, & Hanna, 1999), and use of cocaine and heroin are more prevalent among those who are single or separated compared to those who are married (Heinz, Witkiewitz, Epstein & Preston, 2009).

Unemployment status is strongly correlated with substance use disorders based on data from the U.S. National Survey on Drug Use and Health (Compton et al., 2014). Although those in the poorest socioeconomic status (SES) are more likely to be abstinent from alcohol, those in lower SES are vulnerable to experience more severe alcohol-related health problems, potentially related to lack of available health care or limited social network support (World Health Organization, 2014). Having a higher SES has been associated with higher rates of binge drinking and marijuana use (Humensky, 2010). Research has also found higher rates of substance use in certain sociocultural groups such as full-time college students between the ages 18-22, American Indians or Alaska Natives, Native Hawaiians or Other Pacific Islanders, and persons reporting two or more races (Substance Abuse & Mental Health Services Administration, 2019). Table 1 includes sociocultural risk and protective factors for addiction.

Emotional, cognitive, and personality factors

Individual and intrapersonal factors that influence substance use and saliency of psychological reinforcement of substances include a range of emotional, cognitive, and personality factors. SUDs are commonly comorbid with personality disorders such as conduct disorder (Conner & Lochman, 2010), antisocial personality disorder (Zucker et al., 1996), and borderline personality disorder (Trull et al., 2000). Despite common use of the term, there is no "addictive personality", yet certain personality traits increase vulnerability to developing SUD (Tsavou & Petkari, 2020). Heavy users of alcohol and drugs tend to score higher on extraversion, neuroticism, sensation seeking, and impulsiveness (Chuang et al., 2017; Walther et al., 2012). In contrast, SUD is associated with lower conscientiousness, cautiousness, dutifulness, and perfectionism (Walton & Roberts, 2004). Grevenstein et al. (2016) found that extraversion was the most crucial personality trait predictor of frequency of alcohol, tobacco, and cannabis use.

Emotional factors also impact addiction and recovery processes, and many with a history of SUD report serious thoughts of suicide (36.8%), anxiety (67.7%) and depression (64.4%) in their lifetime (Keyser-Marcus et al., 2015). Some research indicates that SUD patients scored higher on fear of intimacy and self-differentiation, and lower on confidence and mood regulation compared to the student/community sample (Thorberg & Lyvers, 2010). Individuals with PTSD have higher rates of SUD (Jacobsen et al., 2001) and PTSD patients with SUD are more likely to experience re-victimization than PTSD patients without SUD (Iverson et al., 2013).

Emotion regulation is another factor that impacts substance use behaviors and the strength of psychological reinforcement of substance use. Outward anger expression and poor/avoidant coping skills are related to substance abuse (Eftekhari et al., 2004), thus effective recovery didactics nearly always address coping skills and emotion regulation (Cavicchioli et al., 2019). When applying the outcome

expectancy theory to substance use, it is thought that drug-taking behavior is associated with a desire to have a particular outcome generated by the substance (Leventhal & Schmitz, 2006). Positive expectancies become stronger through personal experiences with the substance and over time causes future substance use to be enhanced. Associations between drug use and its effects can become reinforced when attributed to multiple social groups, and further developed in long term memory as one maintains their substance use (Leventhal & Schmitz, 2006). Personal beliefs about the likely effects of a substance and perspectives on social acceptability influence psychological reinforcement of the substance as well. Similarly, psychological reinforcement is influenced by attributions about the positive and negative effects of substance use, and beliefs about personal ability to control substance use (Leventhal & Schmitz, 2006). Table 1 includes various emotional, cognitive, and personality factors that are related to addiction and recovery.

Changes in cognitions and behaviors

When substance use escalates to addiction, it is accompanied by changes in cognitions and behaviors (American Psychiatric Association, 2013). Priorities, expectancies and attributions about substance use change and behavioral patterns become riskier and less healthy. Clinicians often refer to the "funneling effect" as a term to describe the process by which behaviors become increasingly focused on those that are permissive of substance use. This "funneling effect" is similar to what is described in the DSM-5 as a SUD criterion "important social, occupational, or recreational activities are given up or reduced because of substance use" (American Psychiatric Association, 2013). Behavioral changes consistent with the funneling effect happen as individuals reduce engagement in healthy behaviors that are incompatible with their substance use (e.g. early morning soccer practice, family dinner), and increase their engagement with people and activities that enable or promote substance use. Behavioral changes also often include reduction in healthy activities overall, such as not taking medications, not getting preventive care, not attending to health problems, unhealthy sleep patterns, unhealthy eating patterns, and reduced exercise. Recovery from SUD, on the other hand, involves restoration or establishment of healthy behavioral patterns.

Individuals struggling with addiction typically experience changes in their cognitions related to substance use. Expectancies about the impact of the substance become more distorted, and negative consequences of the substance often are minimized (Leventhal & Schmitz, 2006). Motivation is impacted as substance use escalates motivation to use becomes more powerful and starts to outweigh motivation to engage in other activities. These cognitive and behavioral changes are linked in a feedback loop to the psychological reinforcements of substance use and overtime become stronger (Substance Abuse and Mental Health Services Administration, 2016). Substance use becomes increasingly important due to the lack of competing priorities, and hyperfocus on increased importance of substance-related relationships, behaviors, and activities. The reinforcement of engaging in substance use behaviors become more salient than when substance use held a smaller role in their life.

These cognitive and behavioral changes can be addressed directly as part of recovery efforts. One of the primary goals of treatment for SUD includes a focus on relapse prevention strategies that teach individuals to identify and cope with high-risk situations (Cavicchioli et al., 2019; Larimer et al., 1999), and treatment programs often address these cognitive and behavioral changes by enhancing self-efficacy, educating about substance effects, addressing cognitive distortions, improving healthy behaviors, reducing high risk behaviors, and teaching coping skills to manage problematic thought patterns (Larimer et al., 1999; McHugh et al., 2010).

Implications of the integrated model and future directions

Education, prevention, and consultation

This integrated model was initially developed by the first author as an educational tool for an undergraduate course to collate multiple streams of empirical evidence about the etiology of addiction. It proved very useful in that setting, with students frequently commenting the model improved their understanding about the complexities of addiction development and even helped them understand their own substance use and recovery more clearly. Beyond use in specific classroom courses, this model could be presented to various audiences as an educational and consultative framework for prevention efforts. The nature-nurture framework is particularly useful since that terminology is understood by most of the general public, and it also debunks the idea that addiction is wholly either a biological or social problem. By mapping on to both nature and nurture factors that contribute to addiction, this model can provide a more realistic interpretation of the complexities of SUD and recovery for families and the public. Bringing awareness to the environmental and social factors alongside the biological and genetic factors can promote conscientiousness and compassion about SUD development and recovery challenges. This integrated model could guide the development of prevention programs for schools and workplaces, and teachers and parents could use this model to tailor their discussions with youth to increase the relevance to their own students or children. This model also could be used by organizations trying to address the sources of substance abuse in their communities. Overall, this integrated model has numerous potential applications for education, prevention, and consultation.

Clinical applications

This integrated model has substantial clinical utility, and it is frequently used by the first author in clinical practice. It is a useful for needs assessments, treatment planning, informing forensic evaluations, helping those in recovery better understand their personal factors that contributed to

their addiction, identifying factors important for recovery, clinical program development, and quality improvement initiatives. Applying the integrated model to a particular case in an explicit and structured way could help clients and their loved ones be decreasing shame, increasing hopefulness for recovery, and shaping treatment and recovery goals.

Policy applications

The broadest potential applications of this integrated model are related to policy development and reform. One of the most important distinctions that it makes is between the nature factors, which are less malleable, and nurture factors, which can be altered to minimize risk with thoughtful social services and policies. For too long, drug policies have focus ed on trying to scare individuals out of using substances with the threats of illness, death, incarceration, or loss of other liberties and opportunities. This tactic has proven ineffective, has led to social inequities for minority populations, and has made it more difficulty to effectively address risk and protective factors in our communities. The idea that substance use is solely an individual problem is not supported by the evidence – a multitude of social, cultural, and environmental factors interact with individual risk factors. Sociocultural and environmental risk and protective factors are perhaps the most important to consider, because they have the greatest ability to be impacted by social and public policies. Thus, focusing on social, cultural, and environmental risk and protective factors has the potential to make a greater impact on substance use, addiction, and recovery in our communities. This model provides a useful framework for those discussions.

Future directions

Since this integrated model has demonstrated utility as an educational and clinical tool, future directions include evaluation of the utility of this model in other domains, as well as empirical assessment of the model's validity. Research studies could evaluate the components of this model to test its goodness of fit with data from various samples. Clinicians and researchers could use this model to guide clinical practices and treatment development, and could develop treatment planning and needs assessment tools that are consistent with the model. Educators could utilize this model for presentations to various audiences, including teens, parents, teachers, and families of those struggling with addiction. Parents could use this model to guide their discussions with their children. Policy makers could use this model to evaluate the likelihood of social programs and policies having an impact on substance use in their communities. Anyone can use this model to help them better understand the processes of addiction and recovery faced by themselves or their loved ones. In the current climate of the opioid epidemic and growing awareness of addiction as a public health concern, this integrated model of nature and nurture factors that contribute to addiction and recovery has the potential to shape the national discourse.

Disclosure statement

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