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Sleep and Health Behaviors in a Safety-Net Primary Care Setting

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SLEEP AND HEALTH BEHAVIORS IN A SAFETY-NET PRIMARY CARE SETTING

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

by

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Abstract

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Nearly half of all premature deaths in the United States are attributable to preventable and modifiable health risk behaviors. For decades, the leading behavioral health contributors to morbidity and mortality are tobacco use, physical inactivity, and alcohol consumption. Medication adherence is a relatively less studied yet critical interrelated health behavior that is tied to health and treatment outcomes. Sleep, an important pillar of health, is a daily and modifiable behavior that shows promise as a health behavior facilitator. Better understanding the dynamics of these modifiable health behaviors is essential for the improvement of health promotion, particularly among underserved populations (e.g., racial/ethnic minorities and low-income individuals) who are disproportionately at high risk for adverse health outcomes. As such, the purpose of the current study is to characterize the associations between sociodemographic factors, sleep disturbance, and several health behaviors in a safety-net primary care clinic. Primary care clinics—the largest platform of healthcare delivery in the U.S.—show elevated rates of adverse health behaviors and disturbed sleep. Safety-net clinics are a particularly critical access point given the underserved communities that they serve. As mental health frequently co-occurs with disturbed sleep, we also aimed to examine the unique predictive values of sleep disturbance above and beyond mental health in order to tease apart these two highly comorbid variables. Social support, a key protective factor, was also examined as both a predictor and a moderator of the sleep disturbance—health behaviors associations. Participants (N = 210) were a predominantly low-income, diverse patient sample recruited from an urban safety-net primary care clinic. Findings revealed elevated rates of risky health behaviors among the patient sample. Sleep disturbance was a strong unique predictor of alcohol use, physical inactivity, and medication nonadherence. With the addition of mental health, the unique associations of sleep disturbance and mental health were suppressed for alcohol use. For other health behaviors (e.g., physical activity; medication nonadherence), sleep disturbance either stood alone or with mental health as a significant, unique predictor. Lastly, social support was strongly associated with medication adherence and was not found to moderate any of the sleep—health behaviors associations. Findings highlight sleep's potential as a critical target for health promotion and health behavior change. Reducing the high prevalence of these health risk behaviors has the potential to improve quality of life, promote health, and extend the lives of many. Future work is needed to further disentangle the bidirectional associations between sleep, mental health, and health behaviors. Study implications and possible explanations of the findings are discussed.

Keywords: sleep, health behaviors, mental health, social support, safety-net primary care

Vita

Sahar M. Sabet was born on February 7, 1993. She received her Bachelor of Science in Psychology with a Minor in Spanish at the University of Georgia in 2015. She subsequently earned a Master of Arts in Mental Health Counseling at Boston College in 2018 and a Master of Science in Psychology at Virginia Commonwealth University in 2020. Sahar is currently a fifth-year doctoral student in the Counseling Psychology PhD program at Virginia Commonwealth University.

Chapter 1: Literature Review

Introduction

Nearly half of all premature deaths in the United States are attributable to preventable and modifiable health risk behaviors. Health behaviors include "overt behavioral patterns, actions, and habits that relate to health maintenance, to health restoration, and to health improvement" (Gochman, 1997, p. 3). For decades, the leading behavioral health contributors to morbidity and mortality are tobacco use, physical inactivity, and alcohol consumption (e.g., see McGinnis & Foege, 2013; Mokdad et al., 2004). Given the increasingly high prevalence of these poor health behaviors, and the challenges with modifying them, there is a need to identify other daily activities/behaviors that can facilitate health-promoting behaviors and effectively yield health behavior change.

Sleep is a daily, universal, and modifiable behavior that shows promise as a health behavior facilitator by promoting adaptive cognitive, affective, and emotional states (Grandner, 2019; Patterson et al., 2019). As such, sleep is an understudied and potentially effective point of intervention for promoting other health behaviors. Addressing sleep and other critical health behaviors is particularly relevant for a subset of the population – those attending primary care clinics. Primary care is the largest health care delivery platform in the U.S. and is also a critical point of contact for promoting healthy behaviors. Primary care settings show elevated rates of smoking, alcohol use, low physical activity, and disturbed sleep—each of which have clear, established links with greater all-cause mortality and have each been identified as a major public health problem (e.g., see Grandner et al., 2010a; Schoenborn & Stommel, 2011; U.S. Department of Health and Human Services, 2014; World Health Organization, 2022). Safety-net clinics, a specific subset of primary care, are a particularly critical access point given that they are designed to provide health care services to marginalized and underserved groups who disproportionately face a higher risk for adverse health behaviors and their consequences, including morbidity and mortality. Consequently, the overall purpose of the current study is to examine the role of sleep disturbances in predicting multiple health behaviors in a safety-net primary care setting. By understanding the role of sleep in promoting health behaviors, we can potentially identify an intervention target for health behavior change among this vulnerable, at-risk population.

Health Behaviors

Research and practice focused on the role of daily, modifiable behaviors in health promotion and disease prevention are critical for improving individual and population health (Painter et al., 2008). Such health behaviors are dynamic, varying across the lifespan, cohorts, settings, and time (Short & Mollborn, 2015). Actions that can be classified as health behaviors are many, including smoking, substance use, physical activity, diet, sleep, physician visits, and medication adherence. These health behaviors, also commonly referred to as health risk behaviors or behavioral health risk factors, are interrelated. They typically co-occur or cluster together, potentially acting synergistically, resulting in greater adverse health consequences including higher chronic disease incidence and severity (Berrigan et al., 2003; Coups et al., 2004; Poortinga, 2007). For example, compared to nonsmokers, smokers consume more alcohol, have poorer diets, and are less physically active (Kranzler et al., 2002; Shah et al., 1993). Importantly, a large majority of adults in the U.S. have at least two of the four leading health risk behaviors—smoking, lack of regular physical activity, unhealthy diet/obesity, and risky/hazardous alcohol use (Coups et al., 2004).

Health behaviors are also not randomly distributed in the population (Poortinga, 2007). Increasingly, attention has focused on social determinants of health behaviors—“upstream” (social, structural, macro-level) influences that play a role in poor health outcomes—in addition to “downstream” (individual-level) influences (Gehlert et al., 2008). Approaches that incorporate historical and social contexts to understanding health behaviors are increasingly important, as structural inequities impacting historically marginalized communities are evidenced to disproportionately and negatively influence health outcomes (Baah et al., 2019; Gehlert et al., 2008; Nelson, 2002; Phelan et al., 2010; Wilkinson, 2005). Such structural inequities stem from the inequitable distribution of power, money, and resources in these communities, which in turn can lead to poverty, lack of access to affordable healthcare services, and greater exposure to racism, discrimination, and stigmatization (Baah et al., 2019; Braveman et al., 2022). A social ecological framework, for example, recognizes that behavior is affected by multiple levels of influence and emphasizes the need to examine individual behaviors within a sociocultural context (Bronfenbrenner, 1977; Golden & Earp, 2012). Theoretical models of health behavior have received substantial attention over the past few decades as they provide a conceptual framework for understanding the complex interplay of factors that influence health behaviors (Conner & Norman, 2017), such as the interaction of cognitive, behavioral, and socioenvironmental factors (i.e., Social Cognitive Theory; Bandura, 1986, 2004) or the influence of attitudes, subjective norms, and perceived behavioral control in shaping the intentions to perform a behavior (i.e., the Theory of Planned Behavior; Ajzen, 1985). Such approaches and frameworks shift the lens from individual attribution and responsibility for health behaviors to recognizing the interplay between complex, dynamic factors and systems, situating individuals in a larger context (Short & Mollborn, 2015).

Given that smoking, physical inactivity, and alcohol use are the top three leading preventable causes of morbidity and mortality, and medication adherence is a relatively understudied yet critical interrelated health behavior that is closely tied to health and treatment outcomes, the present study will focus on these four health behaviors. Reducing the high prevalence of these poor health behaviors and understanding their predictors has the potential to improve quality of life, promote health and well-being, prevent disease, and extend the lives of many. Furthermore, understanding the dynamics of these daily, modifiable health behaviors in a safety-net primary care population is both needed and essential for the improvement of health promotion and treatment efforts among underserved and at-risk groups.

Smoking. Despite cigarette smoking being the leading cause of preventable disease, disability, and death in the U.S., as well as the many public health efforts targeted to reduce smoking prevalence rates, over 34 million (~13.7%) adults continue to smoke in the U.S.; of those, about 3 out of 4 smoke cigarettes daily (Creamer et al., 2019; Jamal et al., 2018). Notably, these rates climb to as high as 48% in some disadvantaged groups, including those who are uninsured, low-income, and low-educated (Perkett et al., 2017). The tobacco epidemic—which includes secondhand smoke exposure—remains one of the biggest public health threats the world has faced and poses a heavy burden across many levels, including public health and the economy (Nuñez et al., 2021). Annually, almost half a million people die from smoking-related diseases in the U.S. (Centers for Disease Control and Prevention, 2020; U.S. Department of Health and Human Services, 2014). In fact, smoking is attributed to 32% of all cancer deaths (including 87% of lung cancer deaths) and 33% of cardiovascular and metabolic diseases, among many others (Jacobs et al., 2015; U.S. Department of Health and Human Services, 2014). In regards to economic costs, the U.S. spends more than $300 billion each year, including at least $225 billion in direct healthcare expenditures and over $156 billion in lost productivity (U.S. Department of Health and Human Services, 2014; Xu et al., 2021). Thus, smoking cessation remains a major public health priority.

Physical Activity. Physical inactivity (alongside poor diet) is the second leading preventable cause of morbidity and mortality (Mokdad et al., 2004). According to the U.S. Department of Health and Human Services (2008, 2018) and World Health Organization (2021), adults should engage in at least 150 minutes of moderate-intensity, or at least 75 minutes of vigorous-intensity, aerobic physical activity each week. An important group of determinants of physical activity are socioeconomic factors, including age, sex, race/ethnicity, marital status, employment, income, education levels, health insurance status, smoking status, and BMI category (e.g., see Carlson et al., 2015). For example, data suggests that adults who are nonsmokers, male, younger, white, or Asian or who have higher levels of education and household income are more likely to meet the guidelines for sufficient physical activity (Carlson et al., 2015; U.S. Department of Health and Human Services, 2015). In the U.S., an estimated $117 billion in annual health care costs and about 10% of premature mortality are associated with inadequate physical activity (Carlson et al., 2015; I-M. Lee et al., 2012). The evidence for the health benefits of regular physical activity is clear and well-established—physical activity makes people feel better, function better, and sleep better (Piercy et al., 2018). It also reduces the risk of many chronic diseases (e.g., heart disease, stroke, some cancers, depression), and fosters healthy growth, development, and aging across the lifespan (Piercy et al., 2018; U.S. Department of Health and Human Services, 2015). Despite the clear health benefits, approximately 80% of U.S. adults and adolescents are insufficiently active (Piercy et al., 2018).

Alcohol. Alcohol is one of the most commonly used psychoactive substances in the world and is consumed by the majority of U.S. adults, with 55% of adults reporting alcohol use in the past month (National Institute on Alcohol Abuse and Alcoholism, 2022). According to the 2019 National Survey on Drug Use and Health (NSDUH), approximately 6% of U.S. adults reported that they engaged in heavy alcohol use in the past month and 10.2% of Americans aged 12 and older had Alcohol Use Disorder (AUD; Substance Abuse and Mental Health Services Administration, 2019). Alcohol abuse and dependence is a major contributor to injury, disability, morbidity, and mortality (National Institute on Alcohol Abuse and Alcoholism, 2022; World Health Organization, 2022). Broadly, alcohol abuse is associated with an increased risk of liver disease, heart disease, stroke, sleep disorders, and several types of cancer (e.g., liver, colon, rectum, breast), among others (Esser et al., 2020). Beyond health consequences, alcohol abuse also causes significant psychosocial consequences and economic burdens (e.g., the U.S. spent nearly $250 billion in 2010 towards excessive alcohol use) to individuals and society at large (National Institute on Alcohol Abuse and Alcoholism, 2022). Moreover, there are significant racial/ethnic disparities among alcohol-related problems, including higher rates of health, social, and legal consequences among Black and Latinx men compared to white men (Witbrodt et al., 2014). An estimated 95,000 people die from alcohol-related causes annually, making alcohol the third-leading preventable cause of death in the U.S. after (1) tobacco use, and (2) physical inactivity and poor diet (Mokdad et al., 2004).

Medication adherence. In addition to the three leading health behaviors above that contribute to preventable disease and death, medication adherence is an important, dynamic, and multidimensional health behavior with numerous ties to health and treatment outcomes (e.g., see

Sabaté, 2003). Unfortunately, nonadherence is widespread and its detrimental long-term consequences and adverse outcomes are many.

Adherence in the medical context, which is defined as the extent to which a person's behavior (e.g., taking medications as prescribed, following treatment recommendations, and/or implementing recommended lifestyle changes) corresponds with recommendations from a health care provider (Sabaté, 2003), has been the subject of extensive research over the past several decades (e.g., see Vermeire et al., 2001). Medical nonadherence, by contrast, is the degree to which a person's behavior does not adhere or comply to the treatment recommendations by their healthcare provider. "Medical adherence" is often used as an all-encompassing umbrella term that can include various behaviors (e.g., in relation to medications, following treatment recommendations, implementing lifestyle changes, increasing health behaviors), and is used interchangeably with medication or treatment adherence, compliance, etc. The World Health Organization (WHO) estimates that approximately 50% of patients with chronic health comorbidities are medically adherent in developed countries (Sabaté, 2003). Medication nonadherence, in particular, is associated with poorer health and clinical outcomes (Rozenfeld et al., 2008; Schectman et al., 2002), including higher hospitalization and morbidity rates (Lau & Nau, 2004; Sherbourne et al., 1992; Valenstein et al., 2002), greater risk of preventable medication-related hospital admissions (Howard et al., 2007), and a higher mortality rate—contributing to an estimated 125,000 deaths each year in the U.S. (Ho et al., 2006; Osterberg & Blaschke, 2005; Unni & Farris, 2015). As such, this health behavior is an essential component of achieving favorable health-related goals and outcomes, as well as optimal disease management, and is considered a major public health issue that imposes a substantial burden upon healthcare systems (e.g., costs the U.S. an estimated $100-$300 billion annually; DiMatteo, 2004b;

Osterberg & Blaschke, 2005; Vermeire et al., 2001). Notably, it has been suggested that medication nonadherence be conceptualized and viewed as a diagnosable and treatable medical condition (Marcum, Sevick, et al., 2013).

In medical settings, treatment nonadherence ranges from 15% to 93%, and it is estimated that nearly half of patients forget, misunderstand, or ignore treatment recommendations (Martin et al., 2005). As a result, medical and psychosocial complications as well as poor quality of life are common consequences. Positively, research shows improved health outcomes among diverse patient populations across a variety of medical conditions when patients are adherent (DiMatteo et al., 2002; Sabaté, 2003). For instance, medical adherence has been associated with improved outcomes for patients with alcohol dependence (Aguiar et al., 2012), anxiety disorders (Simpson et al., 2011), and depression (Sirey et al., 2010). It is important to note that a complex intersection of individual-level (e.g., psychosocial factors including confusion, fear, or skepticism about medical treatment; mistrust of medical providers; low mood; hopelessness) and system-level factors (e.g., cultural insensitivity, racism, socioeconomic factors; lack of social support network; language barriers) play a role in the manifestation of nonadherence. For these reasons, the WHO (2003) conceptualizes medical adherence as a multidimensional construct that is affected by the following five dimensions: socioeconomic factors (e.g., race/ethnicity, low level of education or SES), therapy-level factors (e.g., treatment complexity), the healthcare system-related factors (e.g., high cost of medications and specialty services, condition-related factors (e.g., symptoms), and the patient-related factors (e.g., biopsychosocial factors including cognitive impairment, health perceptions).

Sleep

Sleep is a daily, universal, and modifiable behavior that shows promise as a facilitator of other critically important health behaviors. Healthy sleep is increasingly recognized as an important determinant of overall health alongside nutrition and physical activity. Poor sleep (e.g., insufficient sleep duration) has been linked to a number of adverse health consequences across physical, psychological, and cognitive domains (Grandner, 2019). Efforts to examine and address sleep quality are warranted given that poor sleep is an underrecognized public health concern strongly associated with morbidity and mortality (Hale et al., 2020). The sections below will first define sleep, provide a brief overview of its prevalence rates, and links with health.

Defining sleep and its role. To grasp the importance of sleep and all of its impacts, it is first important to understand what sleep is. However, as sleep is profoundly complex—in its process, conceptualization, and measurement—it is challenging to fully and accurately capture "sleep" with a simple definition. Countless definitions of sleep have been proposed, such as the following: "a naturally recurring and reversible biobehavioral state characterized by relative immobility, perceptual disengagement, and subdued consciousness" (Grandner, 2019, p. 3). Sleep ultimately depends on an intricate collaboration between biology (e.g., through a progression of neurophysiological changes in the brain), psychology (e.g., feeling safe and secure; calm mind to lower pre-sleep arousal), and behavior (e.g., reducing noise, turning off the lights, shutting the eyes to initiate sleep), where a deficit in any of these domains will undoubtedly disrupt sleep.

As the importance of healthy sleep continues to gain more attention and focus, and sleep is becoming increasingly recognized as critical to health and functioning, efforts to screen, assess, and treat sleep problems remains undeniably critical and necessary. Broadly, healthy sleep requires adequate duration, good quality, appropriate timing, regularity, and the absence of sleep disturbances or disorders (Watson et al., 2015b). Across the continuum of sleep health, sleep is an essential element of human health, supporting a wide range of systems including immune function, cognition, and emotion regulation (Grandner, 2019). Describing sleep as "poor" or using the term sleep "problems" is often unclear as it can refer to a relatively wide range of problems, from sleep complaints, problems, and symptoms (e.g., difficulty falling/staying asleep, feeling unrested) to disorders (e.g., insomnia, sleep apnea). Sleep "disturbances" is another commonly used phrase that also can refer to a broad range of problems, from frequent awakenings and reduced sleep duration to decreased sleep quality. Although there are many different sleep problems one can experience, there is nonetheless a general consensus on what constitutes sleep as poor, given that most people have experienced it at some level—whether chronic or acute—at some point in their lives. Throughout this dissertation, the term "sleep disturbances" will be used to refer generally to any individual or combination of acute or chronic sleep problem(s), such as: difficulty falling and/or staying asleep, insufficient sleep duration, short total sleep time, frequent awakenings, restless sleep, or poor sleep quality based on subjective and/or objective assessments. The terms "sleep disturbances," "disturbed sleep," and "disrupted sleep" may also be used interchangeably throughout. By contrast, clinical symptoms or disorders will be clearly referred to as sleep "disorders."

Sleep is necessary for life—a universal phenomenon that impacts every person, every day, without exception. For this reason, understanding the prevalence rates of disturbed sleep is critical as poor sleep is a significant unmet public health problem. Despite the abundance of evidence illustrating the links between sleep, health and well-being, millions of people continue to report poor sleep, including insufficient sleep and the associated daytime sleepiness. Based on a Centers for Disease Control and Prevention (CDC) report analyzing the 2014 Behavioral Risk

Factor Surveillance System (BRFSS) data, more than one third of U.S. adults are not getting the recommended amount of sleep (e.g., at least 7 hours for adults; Liu et al., 2016; Watson et al., 2015a). Another analysis of CDC data shows that between 1985 and 2012 mean sleep duration decreased and the percentage of adults sleeping ≤ 6 hr in a 24-hr period drastically increased. Specifically, the number of U.S. adults sleeping ≤ 6 hr in a 24-hr period nearly doubled, from 38.6 million to 70.1 million (E. S. Ford et al., 2015). In 2014, the CDC recognized this progressive decline in sleep duration a public health epidemic (Watson et al., 2015a).

Sleeping less than 7 hours per night (i.e., insufficient sleep) on a regular basis is associated with a wide range of adverse health outcomes, including increased risk for obesity, diabetes, hypertension, cardiovascular disease, stroke, cancer, frequent mental health distress, and all-cause mortality (Grandner et al., 2010b, 2014). Additionally, insufficient sleep is bidirectionally associated with many important processes, behaviors, conditions, and diseases—from immunity (Besedovsky et al., 2019) to alcohol use (Marjot et al., 2021) and depression (Riemann et al., 2001). Insufficient sleep—independent of primary sleep disorders—contributes to a number of molecular, immune, and neural changes that play a role in the development of disease (Luyster et al., 2012). Furthermore, insufficient sleep is also associated with poorer general health, increased pain, impaired performance, weakened immune function, and greater risk of accidents (Watson et al., 2015b).

Insufficient sleep has, in turn, the negative consequence of impaired daytime functioning. The National Sleep Foundation's (NSF) 2020 *Sleep in America®* poll finds that nearly half of Americans feel sleepy anywhere from three to seven days a week, with 62% trying to "shake it off" as their primary response. Many respondents indicated their daytime sleepiness interferes with their daily activities, mood, and mental acuity. Those who feel sleepy five to seven days a week reported especially higher rates of somatic complaints such as headaches and feeling generally unwell. Nearly half reported feeling sleepy can impact their ability to focus their thoughts, engage in exercise, and be productive. Importantly, more Americans indicated their daytime sleepiness is due to their poor quality of sleep rather than a lack of time for sleep (National Sleep Foundation, 2020).

In addition to insufficient sleep and daytime sleepiness, specific sleep complaints are reported by a significant portion of the general population. For example, Grandner and colleagues (2012) found that the rate of general sleep disturbance in the U.S. population was approximately 16% in men and 21% in women, and general daytime fatigue was 18% in men and 26% in women. Regarding specific sleep complaints, data from the National Health and Nutrition Examination Survey (NHANES) conducted by the CDC reveals the prevalence of self-reported sleep latency greater than 30 minutes was 18.8%. The prevalence of experiencing difficulty at least once per week was 19.4% for falling asleep, 20.9% for resuming sleep during the night, and 16.5% for early morning awakenings. In this nationally representative sample, ~18% of respondents reported they "often" experience non-restorative sleep (e.g., "*How often did you feel unrested during the day, no matter how many hours of sleep you have had?*"), and nearly 11% reported "almost always." This study was the first comprehensive study to illustrate how sleep disparities/disturbances are differentially experienced across sociodemographic factors such as race/ethnicity, age, education level, poverty, access to private insurance, and food insecurity (Grandner et al., 2013).

Although we all experience disturbed sleep at some point, sleep disturbances at its most extreme can result in *disordered* sleep. Insomnia is a prevalent disorder in the U.S. and the most commonly reported sleep problem, with approximately 6% to 10% of the general adult population likely meeting diagnostic criteria for this disorder (D. E. Ford & Kamerow, 1989; Morin et al., 2006; Ohayon, 2002; Ohayon & Reynolds, 2009). Importantly, the prevalence of insomnia symptoms is remarkably higher with over one third of adults reporting at least one symptom of insomnia (i.e., difficulty initiating or maintaining sleep; early-morning awakening) and 10% to 15% of the population reporting daytime consequences of insomnia (Ohayon, 2002). Unfortunately, despite the high prevalence of sleep disorders in the general population, they also remain poorly identified and largely undiagnosed; for example, merely less than 20% of individuals with insomnia are correctly diagnosed and treated (Ohayon, 2011).

Sleep and Health Behaviors

Sleep is inextricably and bidirectionally linked to health behaviors. For example, studies examining the effects of tobacco, physical inactivity, and alcohol on sleep clearly indicate they are associated with, and contribute to, sleep disturbances. However, the primary focus of existing research has been on sleep as the outcome. Therefore, less is known about if and how sleep can promote or inhibit other health behaviors. As such, in the following sections, the research linking health behaviors to sleep is presented first, followed by the smaller body of research examining sleep as a predictor of health behaviors.

Sleep and smoking. As a clinically recognized and verified symptom of nicotine withdrawal, insomnia is reported by up to 42% of abstinent smokers, while up to 80% of smokers experience sleep disturbances, that then become exacerbated following cessation (J. Hughes, 2007; Jaehne et al., 2015; Zhang et al., 2008). Plentiful data suggests that smokers have poorer sleep and are more vulnerable to various sleep deficits and sleep-related complaints than nonsmokers (e.g., see Patterson et al., 2016). Broadly, smoking has been associated with an array of sleep disturbances, including changes in the basic structure of sleep (i.e., sleep architecture), poorer sleep continuity (e.g., sleep onset latency, sleep efficiency, number of awakenings), and greater insomnia symptoms (Grandner, 2019; Patterson et al., 2019). In general, smokers are at an increased risk for insomnia (Brook et al., 2012), are more likely to report short and long (≤6 and ≥9 h) sleep duration (Mehari et al., 2014; Patterson et al., 2016), and spend significantly more time awake after sleep onset than nonsmokers (Patterson et al., 2019; Soldatos et al., 1980).

More specifically, studies examining sleep architecture suggest that smokers spend more time in shallower, more disturbed sleep-states (i.e., N1) than nonsmokers (Sahlin et al., 2009; Zhang et al., 2006). From a sleep continuity perspective, smokers are more vulnerable to longer sleep latency (e.g., take longer to fall asleep), more nighttime awakenings, delayed sleep time, and shorter sleep duration as measured by polysomnography (PSG; Branstetter et al., 2016; Jaehne et al., 2012; Patterson et al., 2019). Similarly, subjective assessments reflect consistent findings, with smokers reporting more daytime sleepiness, feeling unrested, and increased perceptions of insufficient, poor-quality sleep (Branstetter et al., 2016; Grandner et al., 2015; Liao et al., 2019). Nighttime smoking, a frequent cause of disrupted and shortened sleep, occurs in close to half of smokers (Scharf et al., 2008). Moreover, insomnia is a clinically-recognized nicotine withdrawal symptom (J. R. Hughes & Hatsukami, 1986), and several of the frontline treatments for smoking cessation (e.g., varenicline, transdermal nicotine) can cause sleep disturbances (McClure et al., 2009).

A relatively smaller body of research has examined the alternate directionality of this association: sleep predicting smoking-related behaviors. Short (≤ 6 hr) and long sleepers (≥ 9 hr) had greater odds of being smokers than adequate (7-8 hr) sleepers (Patterson et al., 2016; Patterson, Malone, et al., 2018). Sleep chronotype (i.e., the degree to which an individual prefers the morning or evening) has also been linked to smoking status, with those reporting a later sleep timing (i.e., late chronotype) more likely to be smokers (Patterson et al., 2016). In a large prospective study with 20,000 adults, worsened sleep duration predicted increased cigarette consumption and nicotine dependence across time (Patterson, Grandner, et al., 2018). Moreover, research has also studied the influence of sleep on smoking cessation. For instance, poorer sleep quality (e.g., insomnia symptoms; short sleep duration) before and during the first week of cessation has been identified as a predictor of relapse and is associated with a reduced likelihood of smoking cessation (Peltier et al., 2017).

Taken together, there is strong evidence for the bidirectional association between smoking and sleep, as smokers are more vulnerable to deficits in sleep continuity and architecture, and those with insufficient sleep duration and late chronotypes are at a higher risk to smoke. However, comparatively less is known on the latter directionality of the sleep–smoking association. Moreover, there is compelling evidence that suggests that sleep is an understudied and underutilized intervention target for promoting smoking cessation and preventing relapse in treatment-seeking smokers.

Sleep and physical activity. It has long been recognized that physical activity is associated with better sleep. Physical activity and sleep are interrelated behaviors that are vital to optimal health and functioning (Grandner, 2019). In fact, regular exercise is one of the most common sleep hygiene recommendations (Irish et al., 2015) and a growing body of evidence shows potential for exercise as a nonpharmacological treatment option for disturbed sleep (Buman & King, 2010; Kline, 2014). In general, lower levels of physical activity have been consistently linked with a higher likelihood of reporting sleep disturbances and insomnia (Sherrill et al., 1998; Zheng et al., 2017). By contrast, physical activity is associated with increased total sleep time and sleep duration, decreased sleep latency and use of sleep medications, and improved sleep quality (Kredlow et al., 2015; P.-Y. Yang et al., 2012). Evidence also suggests that physical activity reduces the likelihood and severity of insomnia across both observational and experimental research (Kline et al., 2013; Passos et al., 2012; Spörndly-Nees et al., 2017). In a large study on adults across the lifespan, those who engaged in higher levels of moderate to vigorous physical activity were less likely to report a diagnosed sleep disorder compared with those who were less active (Farnsworth et al., 2015). Moreover, although in its early stages, evidence on the link between sedentary behavior and sleep thus far is clear and compelling. For example, greater sedentary behavior has been associated with greater sleep disturbances, including 18% greater odds for insomnia and 38% greater odds for general sleep disturbance (Y. Yang et al., 2017), as well as lower sleep efficiency (Gubelmann et al., 2018), higher daytime sleepiness and feeling unrested (Loprinzi et al., 2014), poorer sleep quality (Buman et al., 2015; Vancampfort et al., 2018), reduced sleep duration (Vancampfort et al., 2018), and a higher likelihood of reporting a diagnosed sleep disorder (Farnsworth et al., 2015).

Although research on the association between physical activity and sleep has generally focused on the impact of exercise on sleep, more recent research has noted how disturbed sleep may also impact physical activity levels (e.g., see Kline, 2014); importantly, many of these studies are limited to cross-sectional designs and were focused on older adults or adults with chronic pain, diabetes, and/or obesity. A small number of longitudinal studies have found that disturbed sleep predicts lower levels of physical activity 2 to 7 years later (Haario et al., 2013; Holfeld & Ruthig, 2014). When compared to healthy sleepers, adults with short sleep duration or later sleep timing have less physical activity and greater sedentary behavior (Booth et al., 2012; Shechter & St-Onge, 2014). Moreover, experimentally restricting sleep to 4 to 5.5 hr/night for 1 to 7 nights in adults led to reduced daytime activity and/or increased sedentary behavior (Bromley et al., 2012; Tajiri et al., 2018). Taken together, this growing body of evidence suggests that poor sleep may play a key role in initiating and/or maintaining a physically active lifestyle.

Sleep and alcohol. Alcohol is also widely regarded to profoundly impact sleep. Sleep disturbances are longitudinally and bidirectionally associated with alcohol use (Grandner, 2019; Marjot et al., 2021). Therefore, trouble with either of these health domains has the potential to impact the other and create an ongoing, negative feedback loop. Our understanding of alcohol's effect on sleep has improved dramatically over the last few decades. However, the effects of alcohol on sleep remain complex and frequently misunderstood by the general public, perhaps because it is often viewed as an appealing hypnotic and frequently consumed as a sleep aid, largely in part due to the belief that alcohol will help with sleep (e.g., sleep latency; M. B. Miller et al., 2021; Thakkar et al., 2015). Although alcohol (at all quantities) initially produces a reduction in sleep onset latency and a more consolidated sleep during the first half of the night, it then causes an increase in disrupted and fragmented sleep during the second half of the night (Ebrahim et al., 2013). In general, alcohol use is linked to overall poorer objective and subjective sleep quality, including increased sleep fragmentation, greater time spent awake after sleep onset, and reduced sleep duration (Chakravorty et al., 2016; Ebrahim et al., 2013). Approximately half of heavy drinkers report clinically significant sleep disturbances (e.g., greater insomnia symptoms, excessive daytime sleepiness, altered sleep architecture), with increased rates of up to 91% for insomnia among those with AUD (Canham et al., 2015; Chakravorty et al., 2016; Kenney et al., 2013).

Importantly, sleep problems have also been linked to subsequent alcohol use or alcohol use disorder (Hasler et al., 2016; M. B. Miller et al., 2017; Wong et al., 2015). Poor sleep quality and daytime sleepiness have been associated with higher rates of alcohol drinking, potentially becoming a gateway to excessive alcohol use (Roehrs & Roth, 2001). Individuals with insomnia have shown a preference for alcoholic drinks over non-alcoholic drinks, as well as alcohol over hypnotic medications (Kaneita et al., 2007; Roehrs et al., 1999). Disturbed sleep and insomnia is well-recognized during all stages of alcohol use disorders including active use, immediate withdrawal, and during early recovery (e.g., see Chakravorty et al., 2016). Furthermore, research suggests that those with sleep disturbance are more likely to relapse than those with healthy sleep, as evidenced by both objective and subjective indicators of sleep disturbance (Brower, 2001).

Overall, although there is evidence for a bidirectional link between sleep and alcohol, the majority of this work has extensively focused on alcohol’s effects on sleep. Further investigation of sleep’s role in alcohol use and the mechanisms underlying this relation remain important tasks for prevention and treatment efforts.

Sleep and medication adherence. A limited body of research exists examining the association between sleep and medical adherence; however, the bulk of this work has focused on very specific clinical populations and treatment regimens, such as adherence for CPAP in obstructive sleep apnea (Platt et al., 2010), sleep restriction or stimulus control as behavioral treatments for insomnia (Riedel & Lichstein, 2001), treatment regimens for chronic illnesses such as HIV and diabetes (Chasens et al., 2013), or in assessing adherence as a critical predictor of health outcomes in solid organ transplant candidates (Gutierrez-Colina et al., 2019). The small existing body of literature tying sleep to medication adherence has found that sleep disturbance is strongly associated with a lower likelihood of medication adherence (Gay et al., 2011; Marcum, Zheng, et al., 2013; K. D. Phillips et al., 2005; Segrin & Passalacqua, 2010). Nearly 75% of low adherers have reported sleep disturbances, which is not surprising given that “forgetting” has been identified as the most common reason for medication nonadherence; additionally, more than one third of patients report that they slept through their dose time (Gay et al., 2011). In another study, sleep disturbances and depression were identified as barriers to adherence (K. D. Phillips et al., 2005). For example, patients who endorsed more severe depressive symptoms were more likely to fall asleep through the dose time and perceive that they had too many medications to take than those with mild depressive symptoms. Further, poor sleepers were more likely to forget medications, want to avoid the side effects of medications, not want others to notice them taking their medications, fall asleep through the dose time, have difficulty with taking medication at specified times, and run out of pills than healthy sleepers. Of note, both of these studies were conducted on adults with HIV. Although the relation between sleep and medication adherence has not been investigated fully, the small existing research demonstrates an important link between the two, with sleep disturbance identified as an important risk factor for poor adherence. Further examination of this association is warranted as healthy sleep can lead to better adherence, improved treatment and health outcomes, as well as quality of life.

Mechanisms Linking Sleep to Health Behaviors

Taken together, it is evident that the relationships between the aforementioned health behaviors and sleep are vastly complex with increasing recognition towards their bidirectional associations. An extensive body of literature has examined the effects of health behaviors—such as smoking, alcohol use, and physical inactivity— on sleep. In fact, the study of alcohol’s effects on sleep dates back to the late 1930s (Kleitman, 1939). Conversely, the literature on sleep predicting these health behaviors and potential mechanisms through which these relations may occur remains relatively scarce and less understood. For instance, the effects of exercise on sleep are well known and widely accepted with potential pathways for this directionality including temperature regulation (Dzierzewski et al., 2014) and anxiolytic and antidepressant effects (Grandner, 2019) yet comparatively less is known about *why* poor sleep may impede physical activity.

Although the empirical evidence tying sleep to health behaviors is relatively scarce, there are several potential mechanisms through which poor sleep may impact engagement with health behaviors, with cognitive, affective (e.g., mood, depressive symptoms), and emotional (e.g., emotional dysregulation) pathways as the leading, frontline hypotheses (Patterson et al., 2019). Broadly, sleep has a multifaceted impact on several major cognitive domains and processes (Deak & Stickgold, 2010; Walker, 2009) that are necessary for implementing health behaviors. For example, sleep loss has been linked to impaired inhibitory control, increased risk-taking and sensation seeking, and impaired cognitive control (e.g., working memory, decision-making, attention), as well as reduced motivation and increased distractibility (Bonnet & Arand, 2003; Grandner, 2019; Taghvaee & Mazandarani, 2022). Deficits in decision-making quality and judgment, as well as impairments in vigilance, sustained attention, and executive functioning, can lead to difficulty making healthy choices and a higher likelihood to engage in poor health behaviors such as substance abuse and unhealthy eating (Greer et al., 2013; Killgore et al., 2006). Sleep deprivation alters functional activation in brain regions associated with reward and punishment, which may increase the expectation that risky decisions will lead to reward; as sleep loss alters reward expectation, individuals may not realize the consequences of their behaviors and actions (e.g., see Grandner, 2019). Sleep disturbance can also inhibit daytime functioning, and common symptoms of poor sleep (e.g., daytime sleepiness, fatigue, and difficulty concentrating) can be pathways to poor adherence (Gay et al., 2011; Thase, 1999). As poor sleep has been shown to predict poorer cognitive function and mood (Nebes et al., 2009; Vanderlind et al., 2014), tobacco use can be used to ameliorate cognitive deficits (Myers et al., 2008) and improve mood and emotional states (Kendall et al., 2022). Thus, the common heightened cognitive and mood deficits that follow poor sleep may then necessitate greater nicotine use to ameliorate these deficits (Patterson et al., 2018). Healthy sleep impacts major health systems, such as mood (Mccrae et al., 2008) and pain (Finan et al., 2013), which in turn may impact physical activity or other health behaviors. Perhaps more obvious, individuals who achieve a restful night of sleep typically awaken the next day with sufficient energy to engage in increased levels of activities such as exercise (Holfeld & Ruthig, 2014). This is not surprising when considered in light of the fact that one of the most common symptoms of poor sleep is increased fatigue and reduced physical and mental energy (Dinges et al., 1997), as well as decreased alertness and vigor (Bromley et al., 2012). Thus, better sleep quality should presumably lead to greater motivation to engage in regular physical activity, likely as a result of increased energy levels commonly associated with good sleep.

In addition to changes in cognition, mood, and emotional states, there is recent emerging evidence that sleepiness may be a mechanism behind the detrimental effect of poor sleep on health, including physical and mental health, as short and disturbed sleep increases the risk for negative health outcomes and a sedentary lifestyle. Through this conceptual framework, sleepiness functions as a dynamic motivational drive that promotes sleep-preparatory behaviors and competes with other drives and desired outcomes (Axelsson et al., 2020). Sleepiness is associated with an increased desire for safety-seeking and both the preservation and utilization of resources towards sleeping, as a primary function of sleepiness is to prepare to sleep, and a decreased inclination and motivation towards engaging in other competing behaviors—including health behaviors. Sleepiness reduces the motivation to engage in social (e.g., spending time with friends, socializing with a stranger) and physical activities (e.g., walking, exercising), which has important implications for quality of life and health behaviors and outcomes (Axelsson et al., 2020). This theoretical framework proposes that targeting and reducing sleepiness may aid individuals in managing a healthier lifestyle and, importantly, engaging in greater health behaviors. Thus, it is possible sleepiness results in avoidance of, and reduced tolerance to, engage in health behaviors such as physical activity or resisting tobacco and/or alcohol.

Sleep Disturbance and Health Behaviors in Primary Care

Both poor sleep and maladaptive health behaviors are a growing public health concern. Although both sleep problems and adverse health behaviors are highly prevalent in the general population, their rates are in fact higher in primary care. The sections below will first define primary care and introduce safety-net primary care, as this is an especially crucial point of contact for underserved and marginalized patients and communities. Next, sleep disturbances in primary care will be discussed, followed by health behaviors in primary care. As a much smaller body of research has examined these constructs in safety-net primary care, the review below will focus on the general primary care population.

Defining primary care and its role. Since its first introduction in 1961 (K. L. White et al., 1961), primary care remains the largest platform of health care delivery in the U.S., and is considered to be the foundation of efficient and effective healthcare (Donaldson et al., 1996; Willis et al., 2020). In fact, data suggests that more people seek primary care than any other type of healthcare service (Willis et al., 2020), and it is where patients often go first for their medical, mental, and behavioral healthcare (O'Loughlin et al., 2019). The Institute of Medicine (IOM) defines primary care as the "provision of integrated, accessible health care services by clinicians who are accountable for addressing a large majority of personal health care needs, developing a sustained partnership with patients, and practicing in the context of family and community" (Donaldson et al., 1996, p. 1). This definition proposed by the IOM Committee on the Future of Primary Care highlights several critical elements, including the integration and accessibility of health care services, accountability of clinicians and systems for quality of care, the broad scope of health care (e.g., behavioral and mental health) provided, and the importance of a sustained partnership between patients, clinicians, and the community at large.

Safety-net primary care. Safety-net primary care clinics are a specific subset of primary care resources that provide health services to a wide range of underserved, vulnerable, and historically marginalized populations for free or at a drastically reduced cost. For example, those who are poor, are without housing, are of racial or ethnic minority and/or immigrant status, have limited English proficiency, or who live in geographically or economically disadvantaged communities must rely disproportionately on the safety-net setting for their health care. These clinics are often funded by outside parties, such as government agencies and/or private donations, in order to offset healthcare costs for patients (Institute of Medicine, 2000). As a result, those who are uninsured or underinsured are ensured access to a typically comprehensive range of care, including primary care, dental care, behavioral health, social work services, and more that they may not otherwise receive. As such, safety-net primary care clinics provide a "one-stop shop" for patients to seek and receive care for their various, multifaceted needs (Association of State and Territorial Health Officials, 2021; Quan et al., 2011). For example, a substantial and growing proportion of frontline outpatient mental health care in the U.S. is delivered through these sites (both safety-net clinics and non; Olfson, 2016). In fact, 59% of psychotropic medications are prescribed by general practitioners (Mark et al., 2009; Olfson, 2016).

Due to a complex intersection of systemic barriers and stigma, underserved low-income and racial/ethnic minority populations often seek services through primary care, even for purely mental health related concerns (e.g., symptoms related to depression, anxiety, grief), and are more likely to seek help and receive care in primary care as opposed to specialty care (Institute of Medicine, 2000; U.S. Department of Health and Human Services, 2001; VanderWielen et al., 2015; World Health Organization, 2008). For example, Black Americans are far more likely than their white counterparts to receive mental health care from a primary care provider (PCP) than a mental health provider (U.S. Department of Health and Human Services, 2001). Racial and ethnic minority and socioeconomically disadvantaged populations face a range of barriers that reduce their ability to access health services, maintain adherence to treatment, and achieve favorable treatment outcomes (Alegría et al., 2016; Bartels et al., 2004; U.S. Department of Health and Human Services, 2001; VanderWielen et al., 2015). Nevertheless, receiving health services within primary care is evidenced to reduce stigma and allows for easier access to services in a trusted medical setting where patients have established relationships and trust with their medical team (Bridges et al., 2014; O'Loughlin et al., 2019).

Sleep disturbances in primary care. Sleep disturbance (alongside chronic pain) is one of the most common presenting problems in primary care (Jank et al., 2017). As the rates of sleep disturbance has been well documented in the general population, there is an increased need to address sleep disturbances in the primary care population for multiple reasons. A growing body of evidence suggests the primary care population has a higher prevalence of sleep disturbances and disorders than the general population (e.g., see Aikens & Rouse, 2005; Almeneessier et al., 2018; Ancoli-Israel & Roth, 1999; Bjorvatn et al., 2017; Kushida et al., 2000; Shochat et al., 1999; Ulmer et al., 2017). PCPs represent the "frontline" of healthcare treatment (Donaldson et al., 1996; Willis et al., 2020) and are typically the first point of contact/physician to encounter patients who have sleep problems (Kushida et al., 2000; Ulmer et al., 2017). Further, sleep disturbances are highly comorbid with other existing medical (e.g., obesity, hypertension, chronic pain) and psychological symptoms and disorders (e.g., depression, anxiety, trauma), which are also frequently first encountered by PCPs (Bjorvatn et al., 2017; Kushida et al., 2000; Shochat et al., 1999). Sleep disturbances have consistently been found to be highly prevalent among patients in primary care, with rates ranging from 32% up to 69% of primary care patients meeting criteria for insomnia (Bjorvatn et al., 2017; Kushida et al., 2000; Shochat et al., 1999; Vinson et al., 2010), as opposed to the estimated 6% to 10% of the general adult population (D. E. Ford & Kamerow, 1989; Morin et al., 2006; Ohayon, 2002; Ohayon & Reynolds, 2009). Sleep disturbances are frequently initially reported in primary care clinics, which have seen an increase in the number of patients presenting with insomnia as their primary presenting health concern (Bailes et al., 2009; Bjorvatn et al., 2017; E. S. Ford et al., 2014; Ulmer et al., 2017). A report from nearly 20 years ago found a remarkably high rate of excessive daytime sleepiness and feeling unrested after sleep also among adult primary care patients, where 19.8% of men reported not feeling rested after their sleep and 22% reported excessive daytime sleepiness "almost every day," compared to 28.7% and 28.6% for women, respectively; nearly one-third of these patients met criteria for sleep apnea (Netzer et al., 2003). Furthermore, Ford and colleagues (2014) examined national trends in outpatient medical visits for sleep-related difficulties and prescriptions for sleep medications between 1999 and 2010. The number of office visits for which adult patients sought care for any sleep disturbance increased by nearly 30% during this period. There was also a striking increase (293%) in the number of prescriptions for any sleep medication provided, as well as in the percentage of office visits resulting in a sleep medication prescription, such as for benzodiazepine receptor agonists (~430%) or any sleep medication (~200%).

The prevalence of sleep disturbances in primary care is high, yet rates may even be an underestimation as evidence also suggests patients underreport their sleep-related symptoms to their physician (Bailes et al., 2009; Ulmer et al., 2017). Although sleep-related problems are easily recognizable, patients are often not aware of the magnitude untreated sleep problems hold for one's health and well-being (e.g., impact on mood, energy) as well as the variety of comorbid conditions associated with untreated sleep disorders (e.g., obstructive sleep apnea and hypertension). As a result, patients frequently will not discuss their sleep problems (even when a primary sleep disorder exists) with their physician (Bailes et al., 2009) because they consider these problems to be a low priority compared with other health problems (Kushida et al., 2000). Interestingly, there is also evidence that physicians themselves also view sleep disturbance as less important than other medical issues. Multiple studies suggest that PCPs tend to focus on perceived causes of insomnia rather than the insomnia itself, largely by viewing sleep disturbances as symptoms of another health-related (e.g., medical, mental health) problem(s), rather than as a primary concern that should be addressed and treated on its own (Bailes et al., 2009; Bjorvatn et al., 2017; Kushida et al., 2000; Ulmer et al., 2017). When patients do report their symptoms, many feel they need to "convince" their physician of the seriousness and impact of their sleep problems (Dyas et al., 2010).

Health behaviors in primary care. In addition to addressing sleep disturbances, the primary care setting provides an opportunity for healthcare providers to identify and address risky, yet modifiable, health behaviors. The majority of the adult population in the U.S. has received primary care services in the past year (Stange et al., 2002) and approximately 40% of patients have had the same physician for over five years (Davis et al., 2002). The longitudinal nature of primary care provides ample opportunities for physicians to provide health behavior counseling over long periods over time (Goldstein et al., 2004). Patients expect to receive information regarding preventative health measures (Kottke et al., 1997), placing providers—particularly primary care providers—in the unique position to screen and counsel patients on their health risk behaviors and intervene at multiple "teachable" moments (Coups et al., 2004; Stange et al., 2002).

Available studies indicate a higher prevalence of adverse health behaviors in primary care compared to the general population (e.g., see Bradley, DeBenedetti, et al., 2007; Chan et al., 1994; Cherpitel & Ye, 2008; Fleming et al., 1997; Manwell et al., 1998; McNeely et al., 2015; S. M. Phillips et al., 2014; Pilowsky & Wu, 2012; Vinson et al., 2010). For instance, in a large study conducted on nine primary care practices across six U.S. states, 48% of patients reported risky/hazardous alcohol use over the prior year, 65% reported tobacco use over the past 30 days, and 83% were not meeting physical activity guidelines (Glenn et al., 2018). However, many opportunities for PCPs to intervene are unfortunately missed as research has found that they generally do not spend a lot of time assessing or speaking with their patients about health behaviors, even when clear practice recommendations exist (Coups et al., 2004; Stange et al., 2002; Yarnall et al., 2003). Therefore, existing prevalence rates of these health behaviors in primary care are likely higher as they may not be fully captured. According to data by the

National Health Interview Survey on a sample of over 16,800 U.S. adults, nearly 30% of the sample reported they were not asked about any of the four leading risk health behaviors during their last routine medical appointment (Coups et al., 2004).

In general, a review of the literature suggests that a relatively smaller yet growing body of research has closely examined these health behaviors in primary care compared to the general population. Conversely, there is a dearth of research examining sleep and other critically important health behaviors in the safety-net primary care population. Many studies have focused exclusively on isolated behavioral risk factors (e.g., tobacco use) in subpopulations (e.g., diabetics; Glenn et al., 2018). Furthermore, given the ongoing challenges that continue to be present with addressing health behaviors within a primary care setting, a bulk of the literature is focused on screening, assessment, and treatment approaches (Feldman & Berkowitz, 2012; Funderburk et al., 2018; Goldstein et al., 2004; Krist et al., 2016; O'Loughlin et al., 2019; S. M. Phillips et al., 2014; Pilowsky & Wu, 2012; Stange et al., 2002; Webb et al., 2016), as well as patient satisfaction and providers' perspectives, confidence, and perceived effectiveness in managing these health behaviors (Cheung et al., 2014; Davy et al., 2013; Sherman & Hooker, 2020). Nevertheless, given the heavy burden and elevated rates of behavioral health issues in primary care, these settings are particularly important sites for the effective promotion of health behaviors, and efficiently identifying and addressing these co-occurring behavioral health risk factors in this setting is undeniably critical.

Social Support as a Protective Factor

Although the primary objective of the current study is to examine the links between sleep disturbance and leading health behaviors, social support is a potentially potent protective factor in this association that is worth examining. The link between social support and health has received considerable attention in areas of health psychology and behavioral medicine, with decades of research supporting its link to a variety of health outcomes, as well as both morbidity and mortality (e.g., Cohen, 1988; Holt-Lunstad et al., 2010; Uchino, 2004). Social support has consistently been shown to be a strong protective factor for mental health (e.g., stress, depression, suicide; Cohen & Wills, 1985; Gariépy et al., 2016; Kleiman & Liu, 2013) and behavioral health outcomes (e.g., sleep, weight management, chronic pain; Grandner et al., 2015; Kent de Grey et al., 2018; Pow et al., 2017). In addition to its buffering effect, social support is considered to influence health directly by enhancing health (Logsdon et al., 1994; Uchino, 2006). This multidimensional construct is vital to health and well-being through indirect and direct pathways like buffering stress, influencing affective states, and/or changing behaviors (Cohen, 1988; Uchino et al., 2012). As suggested in theory (e.g., health behavior theories) and empirically supported across many studies and populations, social support can help promote and enhance health behaviors such as physical activity, healthy diet, and decreased tobacco and alcohol use (Debnam et al., 2012; Honda & Kagawa-Singer, 2006; Kirchhoff, 2008; Nollen et al., 2005). For example, lower levels of perceived social support predicts poorer health through less sleep, lower medical adherence, and less physical activity (e.g., Debnam et al., 2012; DiMatteo, 2004a). Taken together, there are established and clear links between social support and various health outcomes and health behaviors. Consequently, social support will be examined as an additional predictor of health behaviors in a safety-net clinic population. Furthermore, as less is known about how social support may buffer the links between sleep disturbance and health behaviors, I will also examine social support as a potential moderator.

Purpose of the Current Study

Building on this evidence, the current study aimed to explore the associations between sleep disturbances and multiple health behaviors in a diverse, underserved safety-net primary care sample. Specifically, the following health behaviors were individually examined in the present study: alcohol, smoking, physical activity, and medication adherence. Although a growing body of research has examined these constructs in primary care, considerably less work exists on safety-net primary care, which serves a more diverse, underserved, and historically marginalized patient population. Furthermore, to our knowledge, very few studies have examined sleep disturbance as a predictor of these health behaviors in a safety-net primary care sample. Moreover, as mental health is an important factor to consider as it is highly comorbid with sleep disturbances, and also frequently co-occurs alongside adverse health behaviors such as substance use and physical inactivity, the unique predictive value of sleep disturbance above and beyond mental health was also assessed. Lastly, social support was examined as both a predictor of health behaviors and a moderator of the sleep disturbance—health behaviors associations. As such, the proposed dissertation had the following aims and hypotheses:

AIM I. The first aim of the study is to examine to what extent sociodemographic factors (i.e., age, gender, race/ethnicity, education, and income) are associated with poor health behaviors (i.e., smoking, alcohol use, physical inactivity, and medication nonadherence).

Hypothesis 1. Based on a review of the literature, I hypothesize that underrepresented men with a racial/ethnic minority status of Black, Native American, Latinx, American-Indian/Native-American vs. white or Asian/Pacific Islander, who are younger aged, lower incomed, and hold a lower education will report higher alcohol use and smoking rates. Additionally, younger men who are more educated, have a higher income, and identify as white will be more physically active and adherent to their medication regimens in the present sample.

AIM II. The second aim of the study is to investigate to what extent sleep disturbance is associated with higher rates of poor health behaviors (i.e., smoking, alcohol use, physical inactivity, and medication nonadherence) when controlling for sociodemographic factors.

Hypothesis 2. Greater sleep disturbance will be associated with higher rates of poor health behaviors.

AIM III. The third aim is to assess whether sleep disturbance remains a significant predictor of poor health behaviors (i.e., smoking, alcohol use, physical inactivity, and medication nonadherence) after controlling for mental health (i.e., symptoms of depression and anxiety).

Hypothesis 3. Sleep disturbance will remain a predictor of higher rates of poor health behaviors after controlling for mental health (i.e., symptoms of depression and anxiety).

AIM IV. As there is considerable evidence pointing to the protective role of social support for health outcomes, the fourth aim is to examine the associations between social support and health behavior outcomes (i.e., smoking, alcohol use, physical inactivity, and medication nonadherence).

Hypothesis 4. Higher levels of perceived social support will be associated with lower rates of smoking, alcohol use, physical inactivity, and medication nonadherence.

AIM V. The fifth and final aim is to explore whether social support buffers the associations between sleep disturbance and poor health behaviors (i.e., smoking, alcohol use, physical inactivity, and medication nonadherence).

Hypothesis 5: There will be a significant interaction between sleep and social support when predicting poor health behaviors such that social support attenuates these associations. Higher sleep disturbance will be associated with lower rates of poor health behaviors for those with better social support.

Chapter 2: Methods

Participants

The current study involved archival analyses of data collected as part of the Health Behaviors in an Urban Primary Care Clinic study (IRB # HM20004627). Participants were recruited from an urban, safety-net primary care clinic in Richmond, VA. Inclusion criteria for the study included being at least 18 years of age and a patient of the safety-net primary care clinic. Individuals were excluded if they did not meet a minimum score (≥10) on a brief health literacy screener.

The study sample included 210 adults (60% men) who were predominantly middle-aged (M = 44.69, SD = 11.57), Black (63.8%), and high school educated (53.1%). Of note, the majority of participants were low-income, with nearly 70% reporting a total annual income (including public assistance) of less than $5,000 USD. See Table 1 for participant demographics.

Table 1

Participant Demographics

Variable	Total (%)
Age (mean, SD)	44.69 (11.57)
Range	21 to 67
Gender	
Male	126 (60.0%)
Female	84 (40.0%)
Race/Ethnicity	
Asian/Pacific Islander	1 (0.5%)
Black/African American	134 (63.8%)
Latino/Hispanic	4 (1.9%)
American-Indian/Native-American	3 (1.4%)
White/European-American	57 (27.1%)
Multiracial/Multiethnic	9 (4.3%)
Other	2 (1.0%)
Education	
Elementary school	1 (0.5%)
Middle school/Junior high	18 (8.6%)
High school	111 (52.9%)
Some community college (no degree)	52 (24.8%)
2-year/technical degree	7 (3.3%)
4-year college degree	17 (8.1%)
Master’s degree	3 (1.4%)
Income	
$0-$4,999	146 (69.5%)
$5,000-$9,999	29 (13.8%)
$10,000-$14,999	13 (6.2%)
$15,000-$19,999	9 (4.3%)
$20,000-$24,999	4 (1.9%)
$25,000-$29,999	4 (1.9%)
$30,000+	4 (1.9%)

Note. Age measured in years. Percentages may not be based on the full sample because of missing data.

Procedure

Over the course of six months, patients were recruited from the waiting room via a verbal group announcement from research assistants as they waited for their medical appointment. The exact number of potential participants approached about recruitment are unknown; however, the clinic engages in an average of approximately 170 unique patient encounters per day, suggesting that between 50 and 100 patients heard the study announcement during each data collection day. The purposes of the parent survey—to better understand the current needs of the patients as well as additional experiences that might be important for their health—were described in an announcement and patients could then express interest in participation. Interested participants provided informed consent and were then asked to complete a paper survey while in the clinic's waiting area. Participants were asked to stop completing the survey if and/or when they were called for their appointment in order to prevent any disruption of their clinical health services. They were allowed to bring their survey into the appointment with them and then resume its completion upon returning to the waiting room after their appointment. Participants received $10 (USD) cash upon completion of the questionnaires, which lasted approximately 30 to 45 minutes. This study was approved by Virginia Commonwealth University's Institutional Review Board.

Measures

Sociodemographic characteristics. Participants were asked to complete a brief measure to assess their sociodemographic characteristics, such as age, gender, sexual orientation, race/ethnicity, income, and educational attainment.

Sleep disturbance. Sleep disturbance was measured using the Patient-Reported Outcomes Measurement Information System (PROMIS) Sleep Disturbance Short Form (4a; Yu et al., 2012). Across four items, participants report on their sleep quality, whether their sleep was refreshing, whether they had problems with their sleep, and whether they had difficulty falling asleep over the prior seven days. Each item has five response options that vary depending on the item but that maintain the same range in values (1–5). A total score (ranging from 4–20) was calculated by summing the values of the responses for each item, with higher scores indicating greater sleep disturbance. The PROMIS Sleep Disturbance measure has demonstrated excellent internal consistency (Cronbach's α range between .88 and .95) and construct validity in a large diverse (e.g., with respect to age, race/ethnicity, gender, and education status) community sample (Jensen et al., 2016). Cronbach's alpha in this sample was .87, suggesting good internal reliability within the sample.

Health Behaviors.

Smoking. Participants were asked about their current smoking status by approximating the number of days per week they smoke and the number of cigarettes smoked per day on two self-report items. They were asked to select one of five possible responses for cigarettes smoked per day (0, 1–10, 11–20, 21–30, and 31 or more). Total scores drawn from the number of cigarettes smoked per day item (ranging from 1–5) were used in this study as a continuous variable, with higher scores indicative of higher number of cigarettes smoked per day.

Physical activity. A version of the International Physical Activity Questionnaire Short Form (IPAQ-SF; P. H. Lee et al., 2011) modified for the parent study was used to measure physical activity. Participants were asked to report the frequency in which they engage in 20 minutes or more of physical activity across three different levels of intensity according to their heart rates: (1) light (e.g., walking leisurely or stretching), (2) moderate (e.g., fast walking or lifting weights), and (3) vigorous (e.g., running, jogging, or heavy lifting). Each scale was rated

on a 5-point Likert scale with the following response options available: "*rarely or never*," "*about once a month*," "*about once a week*," "*2-3 days a week*," and "*4 or more days a week*." A continuous score was calculated and reported as median MET (metabolic equivalent of task) minutes per week. Total scores can range from 0 to 640. Current guidelines (U.S. Department of Health and Human Services, 2008) recommend 500 to 1000 MET-minutes per week. By computing average MET values for each participant, we were better able to see a more comprehensive, nuanced picture of what physical activity looks like in this sample.
The scale demonstrated good internal consistency in the current sample (α = .82).

Alcohol use. The Alcohol Use Disorders Identification Test Consumption (AUDIT-C; Bush et al., 1998) is a brief 3-item alcohol screening instrument used to identify persons who are hazardous drinkers or who have active alcohol use disorders (including alcohol abuse or dependence). The items assess the frequency of drinking alcohol, the number of drinks consumed on a typical day, and the frequency to which six or more drinks are consumed on one occasion. Each AUDIT-C item has five response options ranging from 0 to 4. In men, a score of 4 or more is considered positive for identifying hazardous drinking or the presence of an active alcohol use disorder; in women, a score of 3 or more is considered positive. Total scores (summed items) range from 0 to 12, with higher scores indicating greater problematic drinking. The AUDIT-C has significant clinical utility and is commonly used in medical settings (e.g., VA outpatient clinics; Bradley, Williams, et al., 2007) including primary care (Bradley, DeBenedetti, et al., 2007). This measure has been shown to be psychometrically sound and reliable in the general US population, and has been validated in a large primary care sample (Bradley, DeBenedetti, et al., 2007). Cronbach's alpha for the AUDIT-C in the current sample was good (α = .81).

Medication nonadherence. The Morisky Green Levine Medication Adherence Scale (MGLS; Morisky et al., 1986) is a widely used measure that assess participants' medication nonadherence behaviors. The MGLS scale is based on the intentional-unintentional nonadherence classification and identifies these two main types of nonadherence using four items. The first two items measure unintentional nonadherence, which occurs when patients *wish* to adhere to medications but fail to do so due to some reason, and are based on forgetfulness and carelessness in medication adherence. The final two items measure intentional nonadherence, which occurs when patients deliberately do not take their medications, and are based on discontinuing medications when feeling better or worse. Participants endorse either a 0 (*Yes*) or 1 (*No*), and scores are summed to create a total score ranging from 0 to 4, with higher scores indicative of greater medication nonadherence. Previous studies have assessed the psychometric properties (Cronbach's α values ranging from .71–.73) of the MGLS among diverse patient populations (Koschack et al., 2010; Thompson et al., 2000). Within the current sample, Cronbach's alpha was lower (α = .62), suggesting suboptimal internal consistency.

Depression and anxiety. Given the links between mental health, sleep, and health behaviors, symptoms of depression and anxiety were also measured. Specifically, depressive symptoms were measured via the nine-item, Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001). Respondents indicate the frequency with which each item has bothered them over the past two weeks (e.g., "Little interest or pleasure in doing things") using a four-point scale from 0 (*Not at all)* to 4 (*Nearly every day*). Total scores range from 0 to 27, with higher scores indicating more severe depressive symptomatology. A score of three or greater is used as a cutoff—with the best specificity and sensitivity—for detecting major depressive disorder. One item that assesses sleep in the PHQ-9 (item #3: "Trouble falling or staying asleep, or sleeping too much") was removed from the scale prior to analyses in order to avoid conflation with the sleep disturbance measure. There is strong evidence for the reliability and validity (e.g., construct and factor-structure) of the PHQ-9 (Kroenke et al., 2001), which has found to be highly correlated with a depression diagnosis in primary care patients (Henkel et al., 2004).

Anxiety symptoms were measured via the Generalized Anxiety Disorder-7 (GAD-7; Spitzer et al., 2006). The GAD-7 consists of seven items (e.g., "Feeling nervous, anxious, or on edge") scored on a 4-point Likert scale from 0 (*Not at all*) to 3 (*Nearly every day*). Items are anchored over a two-week period. A total score (ranges from 0–21) is obtained by summing all items, with higher scores indicating more severe anxiety. A score of 3 or higher has been determined as having the optimal specificity and sensitivity for detecting generalized anxiety disorder. The GAD-7 is a reliable and valid instrument, demonstrating excellent internal consistency ($\alpha = .92$), as well as good test-retest reliability and convergent validity (Spitzer et al., 2006).

The present study examined mental health as a continuous variable using both the PHQ-9 and GAD-7, also known as the Patient Health Questionnaire Anxiety-Depression Scale (PHQ-ADS; Kroenke et al., 2016). The PHQ-ADS is a 16-item scale that combines the PHQ-9 and GAD-7 scales to create a composite measure of depression and anxiety. The total score can range from 0 to 48, with higher scores indicating higher levels of depression and anxiety symptomatology; however, as item #3 from the PHQ-9 was removed from analyses, the total score in the present study ranged from 0 to 47. The PHQ-ADS has been validated in three clinical trials and has demonstrated good internal reliability, as well as strong convergent and construct validity. Factor analysis has also confirmed sufficient unidimensionality of the PHQ-

ADS to support its use as a composite measure of depression and anxiety (Kroenke et al., 2016). In the present sample, the internal consistency for the PHQ-ADS was excellent (α = .94).

Social support. The Interpersonal Support Evaluation List-12 (ISEL-12; Cohen et al., 1985) was used to measure perceptions of social support (e.g., "I feel that there is no one I can share my most private worries and fears with"), and is a shortened version of the original 40-item ISEL. The ISEL-12 has three different subscales designed to measure three dimensions of perceived social support: appraisal, belonging, and tangible support. Each dimension is measured by four items on a 4-point scale ranging from 0 (*Definitely false*) to 3 (*Definitely true*). All items are totaled to yield a total score (ranging from 0 to 36), with higher scores reflecting greater perceived social support. The ISEL-12 has been widely-used and validated in racially and ethnically diverse populations (Merz et al., 2014). The ISEL-12 in the present sample demonstrated good internal consistency (α = .81).

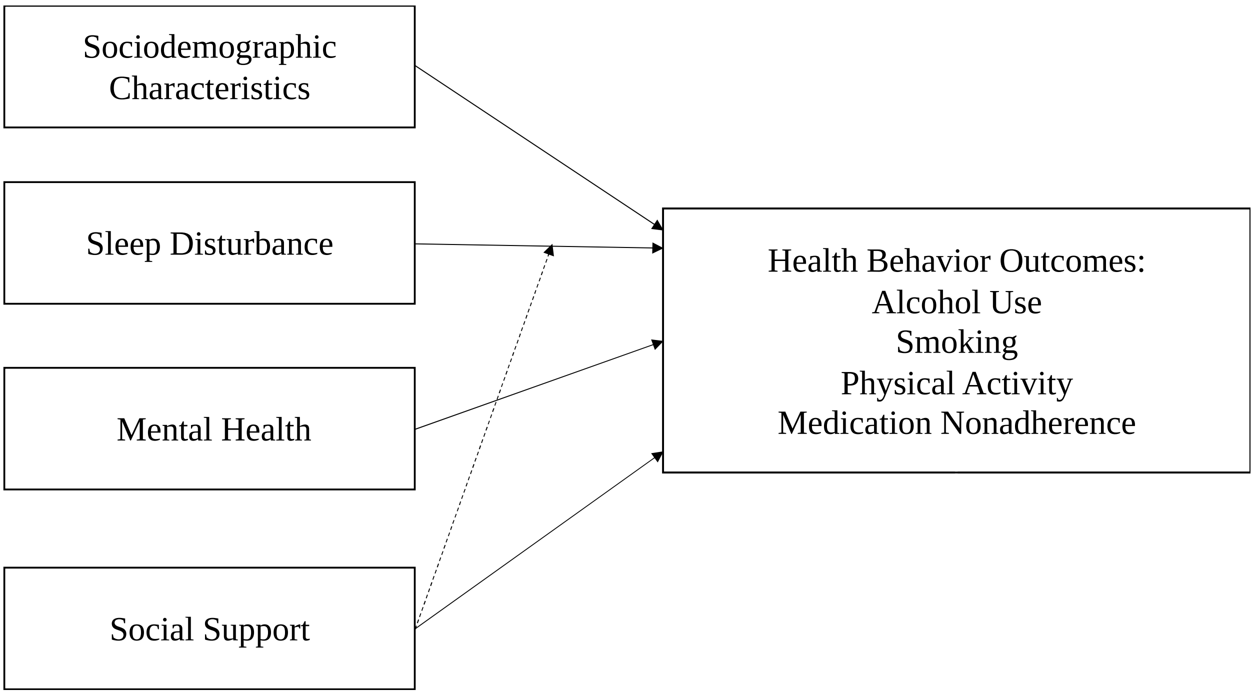
Data Analyses

All analyses were conducted using SPSS version 29 or PROCESS Macro version 4.2 (IBM Corp. 2022; Hayes, 2022). Data were cleaned and descriptive statistics, including means, standard deviations, skewness, and kurtosis values were calculated to verify that data met the assumptions of the following planned analyses. Missing data were evaluated via Little's missing completely at random (MCAR) test, and expectation maximization analyses were used to account for missing values, allowing retention of participants who met inclusion criteria. Dichotomous variables were given a reference point of 0. G*Power was used to conduct a power analysis for the aims of the present study (Faul et al., 2007). A minimum of 103 participants were needed to achieve 80% power, an alpha level of .05, and a medium expected effect size with eight predictor variables for the current study.

To assess the associations between sociodemographic variables, sleep disturbance, mental health (i.e., depression and anxiety), and health behavior outcomes, several hierarchical linear regressions were run, one series for each of the four health behavior variables. In particular, within each health behavior outcome, a three-stage hierarchical multiple regression analysis was conducted. For all analyses, the following sociodemographic variables were simultaneously entered in the first block: age, gender (dichotomous; coded as 0 = male or 1= female), race/ethnicity (dichotomous; coded as 0 = white and Asian/Pacific Islander or 1 = underrepresented minority), income, and education. Sleep disturbance was entered in Block 2, followed by mental health in Block 3. Finally, alcohol use, smoking, physical activity (calculated by each participant's average MET minutes per week), and medication nonadherence were entered as the respective outcome variables. Additionally, in order to examine the associations between social support and health behavior outcomes, separate analyses were conducted with the aforementioned sociodemographic variables controlled. Lastly, Hayes PROCESS Macro was utilized to examine whether social support buffers the associations between sleep disturbance and health behavior outcomes (i.e., interaction term: sleep disturbance x social support). Figure 1 depicts a conceptual model illustrating the variables of interests and their associations with health behaviors for the present study.

Figure 1

A Global, Conceptual Model for the Present Study's Aims



Note. This model is to be interpreted conceptually and not statistically.

Chapter 3: Results

Missing Data

Prior to running the primary analyses, expectation maximization was used to impute missing data using SPSS. Originally, 210 adults participated in the study. Missing data were extremely minimal, with 1% to 4% of items missing within scales. Nonetheless, it was important to address missing data in a thoughtful and nuanced manner in order to attempt to retain as many participants as possible.

To determine whether the data were missing completely at random (MCAR) prior to imputation, Little's MCAR tests were conducted. Each test was non-significant (all p values > 0.936), indicating that the data were missing completely at random and suggesting that multiple imputation was appropriate. Missing demographic data was not imputed. As two participants were missing key demographic data with respect to the study aims, they were removed from the dataset, leaving a sample size of 208. Within each scale, expectation maximization was used at the item level to impute missing data if a participant had at least 50% of the items on a given measure. Seven participants did not meet this 50% cutoff across various variables of interest. For these missing data, a two-step procedure was conducted at both the item level and total score level of a scale; through this process, the participant was retained. Upon utilizing expectation maximization, all remaining participants were successfully retained, and the final sample size for the present study remained 208.

Preliminary Analyses

Normality assumptions were assessed prior to running the primary analyses. All measures met criteria for normality with skewness and kurtosis values $\leq \pm 2$. Means, standard deviations, and percentages of all observed variables were computed and are presented in Table 2. An assessment of the scatterplot for each measurement showed no evidence of outliers. Additionally, data were checked for multicollinearity via correlation coefficients among all predictor variables (all variables had an $r < .70$; Table 3).

In particular, sleep disturbance within this sample was slightly worse than the average rating, with nearly half of the sample rating their sleep quality over the past week as either “poor” or “very poor.” Additionally, 90% of participants reported having problems with their sleep over the past week. Nearly 37% of men and 23% of women in the sample met criteria for hazardous drinking. Similarly, smoking was elevated in the present study as nearly three-quarters of the sample consisted of smokers. On average, participants reported smoking one to ten cigarettes per day. In regards to medication nonadherence behaviors, participants on average fell in the middle of the spectrum (i.e., considered “moderate” non-adherers). Psychological symptoms were pronounced with participants’ average level of depressive symptoms on the PHQ-9 ($M = 11.26$, $SD = 6.86$) and anxiety symptoms on the GAD-7 ($M = 9.66$, $SD = 6.70$) both falling within the moderate ranges. Globally, results indicate that 82.2% and 55.8% of participants endorsed clinically significant symptoms of depression and anxiety, respectively.

As previously mentioned, the average metabolic equivalent of task (MET) values per week was calculated for each participant’s physical activity score. A MET value represents the energy cost for a specific physical activity, allowing for the measurement of an individual’s expenditure of energy (U.S. Department of Health and Human Services, 2018). Physical activities frequently are classified by their intensity using the MET value as a reference, whereby the higher the MET value of a particular activity, the more energy is expended. The current physical activity guidelines (i.e., 150 to 300 minutes of moderate-intensity or 75 to 100 minutes of vigorous-intensity physical activity for adults) is equivalent to 500–1,000 METs a week (U.S.

Department of Health and Human Services, 2018). In the present study, the proportion of the sample who met the recommended physical activity guidelines was only 28%. This is markedly lower than the percentage of US adults (~52%) who currently meet the guidelines (Abildso et al., 2023), which is consistent with what we expected.

A correlation matrix was created to examine bivariate correlations among the study's variables of interests: sleep disturbance, mental health, social support, and health behavior outcomes (Table 3). Although sleep disturbance was associated with alcohol use, physical activity, and medication adherence, bivariate correlations indicated that sleep disturbance was not correlated with smoking in the present sample. Additionally, social support was only correlated with sleep disturbance and mental health, but none of the health behavior variables.

Table 2

Sample Characteristics: Biopsychosocial Health Factors

Variable	Mean (SD) or %
Sleep Disturbance	13.49 (4.22)
Scale range	4 to 20
Alcohol Use	
Meets criteria for hazardous drinking	31%
Men	37%
Women	23%
Smoking	
Smokers	155 (74.5%)
Physical Activity	
Meets physical activity guidelines	28%
Physically inactive	15%
Medication Nonadherence	1.61 (1.33)
Scale range	0 to 4
Depression	11.26 (6.86)
Scale range	0 to 27
Anxiety	9.66 (6.70)
Scale range	0 to 21
Mental Health	19.33 (12.14)
Scale range	0 to 47
Social Support	18.72 (7.39)
Scale range	0 to 36

Note. Mental Health variable excluded the sleep-related PHQ-9 item #3.

Table 3

Correlation Matrix Among Variables of Interest

Variable	1	2	3	4	5	6
1. Sleep Disturbance						
2. Alcohol	.161*					
3. Smoking	.107	.297**				
4. Physical Activity	-.182**	-.039	.061			
5. Nonadherence	.302**	.205**	.000	-.124		
6. Mental Health	.549**	.140*	.149*	-.127	.328**	
7. Social Support	-.389**	-.099	-.045	.023	-.196**	-.489**

* $p < .05$. ** $p < .01$.

Aims I–III: The associations between sociodemographic variables, sleep disturbance, mental health, and health behavior outcomes.

Alcohol Use. In the hierarchical linear regression predicting alcohol use (Table 4), Model 1 was statistically significant, $F(5, 202) = 2.787$, $R^2 = .065$, $p < .05$, and accounted for 6.5% of the variation in alcohol use. However, gender was the only demographic variable that emerged as a significant unique predictor ($\beta = -.210$, $p = .002$), indicating that identifying as male was associated with more alcohol use compared to identifying as female. With the addition of sleep disturbance in Model 2, the overall model remained statistically significant, $F(6, 201) = 3.681$, $p < .01$, and an additional 3.4% of the variance was explained by sleep disturbance. This change in R^2 was statistically significant, ΔR^2 $F(1,201) = 7.69$, $p < .01$. Sleep disturbance was positively and uniquely associated with more alcohol use ($p = .006$) such that greater sleep disturbance was associated with more alcohol use. Adding mental health explained less than an additional 1% of the variance in alcohol use, though the overall model remained statistically significant, $F(7, 200) = 3.416$, $p < .01$. Interestingly, though sleep disturbance and mental health emerged as unique, significant predictors of alcohol use on their own, neither remained significant when included in the model together.

Smoking. In the hierarchical linear regression model predicting smoking (Table 5), Model 1 was statistically significant, $F(5, 202) = 5.58$, $p < .001$, and accounted for 12% of the variation in smoking. Within the model, age, race/ethnicity, and education significantly predicted smoking, while gender and income did not. Specifically, participants who are younger, white or Asian/Pacific Islander, and less educated reported smoking more cigarettes per day compared to participants who were older, an underrepresented minority, and more highly educated. Although the overall model was significant for Model 2, $F(6, 201) = 4.95$, $p < .001$, sleep disturbance as its own was not a statistically significant predictor ($\beta = .09$, $p = .19$). When mental health was entered in Model 3, the overall model also remained significant $F(7, 200) = 3.11$, $p < .001$. However, similar to the patterns observed for alcohol use, neither mental health nor sleep disturbance were individual significant predictors when they were both included as predictors in the same model. Adding sleep disturbance and mental health explained less than 1% of the variation in smoking.

Physical Activity. In the hierarchical linear regression model predicting physical activity, Model 1 was statistically significant, $F(5, 202) = 2.98$, $p < .01$, and accounted for 4.6% of the variation in physical activity. Both age and gender emerged as significant unique predictors of physical activity, indicating that younger adults and men were more physically active. The other demographic variables of race/ethnicity, education, and income did not predict physical activity.

When sleep disturbance was added to the model, the model was significantly improved and it explained an additional 3% of the total variance in physical activity. Model 2 revealed that sleep disturbance significantly predicted physical activity (β = -.176, p < .01), with greater sleep disturbance associated with lower physical activity levels. After the Model 3 addition of mental health, the overall model remained statistically significant, F(7, 200) = 3.17, p < .01, but did not improve significantly with the addition of mental health. Within the model, sleep disturbance remained a unique significant predictor of physical activity (β = -.157, p < .05) above and beyond mental health, which was not a significant predictor of physical activity (p = .66)

Medication Nonadherence. In the hierarchical linear regression model predicting medication nonadherence, Model 1 was not statistically significant, F(5, 202) = .234, p = .947. Demographic variables only accounted for less than 1% of the variation in medication nonadherence, and no demographic variables were significant unique predictors of medication nonadherence (all p's > .05). With the addition of sleep disturbance in Model 2, the overall model became statistically significant, F(6, 201) = 3.76, p < .001, and an additional 9.6% of the variation was accounted for. Sleep disturbance was positively and uniquely associated with higher medication nonadherence (β = .313, p < .001). When mental health was added into the model, it explained an additional 4.5% of the total variance in medication nonadherence, and the overall model improved significantly and remained statistically significant, F(7, 200) = .4.90, p < .001. Within Model 3, both sleep disturbance and mental health symptomatology were positively and uniquely associated with greater medication nonadherence. Specifically, greater sleep disturbance and poorer mental health (i.e., higher symptoms of depression and anxiety) were associated with more nonadherence.

Table 4. *Hierarchical Multiple Regression for Alcohol Use*

Predictor	Model 1			Model 2			Model 3		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Age	.001	.018	.003	.000	.017	.001	.003	.017	.012
Gender	–1.254**	.409	–.210**	–1.382***	.405	–.231***	–1.472***	.410	–.247***
Race/Ethnicity	.089	.456	.014	.209	.450	.032	.282	.453	.043
Education	–.176	.211	–.066	–.176	.208	–.066	–.161	.207	–.060
Income	–.211	.166	–.097	–.198	.163	–.090	–.183	.163	–.084
Sleep Disturbance				0.131**	.047	0.188**	.091	.056	.131
Mental Health							.026	.020	.109
R^2		.065			.099			.107	
R^2 *Change*					.034**			.008	

Table 5. *Hierarchical Multiple Regression Model for Smoking*

Predictor	Model 1			Model 2			Model 3		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Age	–.010*	.005	–.134*	–.010*	.005	–.135*	–.010*	.005	–.128*
Gender	.000	.121	.000	–.018	.121	–.010	–.037	.123	–.020
Race/Ethnicity	–.580***	.134	–.293***	–.564***	.135	–.284***	–.549***	.136	–.277***
Education	–.141*	.062	–.172*	–.141*	.062	–.172*	–.138*	.062	–.168*
Income	.022	.049	.033	.024	.049	.036	.027	.049	.041
Sleep Disturbance				.019	.014	.088	.011	.017	.050
Mental Health							.005	.006	.072
R^2		.121			.129			.132	
R^2 *Change*					.008			.003	

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 6. *Hierarchical Multiple Regression for Physical Activity*

Predictor	Model 1			Model 2			Model 3		
	B	*SE B*	*β*	*B*	*Se B*	*β*	*B*	*Se B*	*β*
Age	–3.605*	2.083	–.120*	–3.571*	2.053	–.119*	–3.674*	2.071	–.122*
Gender	139.900**	48.396	–.198**	125.726**	48.030	–.178**	122.116**	48.813	–.173**
Race/Ethnicity	–18.321	53.907	–.024	–31.575	53.398	–.041	–34.514	53.916	–.045
Education	–26.183	24.948	–.082	–26.190	24.599	–.082	–26.786	24.686	–.084
Income	5.521	19.584	.021	3.973	19.320	.015	3.399	19.402	.013
Sleep Disturbance				–14.510**	5.579	–.176**	–12.924*	6.640	–.157*
Mental Health							–1.050	2.372	–.037
R^2		.069			.099			.100	
R^2 *Change*					.030**			.001	

Table 7. *Hierarchical Multiple Regression for Medication Nonadherence*

Predictor	Model 1			Model 2			Model 3		
	B	*SE B*	*β*	*B*	*Se B*	*β*	*B*	*Se B*	*β*
Age	–.002	.008	–.016	–.002	.008	–.018	.001	.008	.007
Gender	–.010	.191	–.004	–.106	.183	–.039	–.205	.181	–.076
Race/Ethnicity	.169	.212	.057	.259	.203	.088	.339	.200	.115
Education	.061	.098	.050	.061	.094	.050	.078	.092	.064
Income	–.053	.077	–.053	–.042	.074	–.043	–.027	.072	–.027
Sleep Disturbance				.098***	.021	.313***	.055**	.025	.175**
Mental Health							.029***	.009	.262***
R^2		.006			.101			.146	
R^2 *Change*					0.096***			0.045***	

* $p < .05$. ** $p < .01$. *** $p < .001$.

The associations between social support and health behavior outcomes among safety net primary care patients.

Controlling for demographic variables (i.e., age, gender, race/ethnicity, education, and income), social support did not significantly predict (all *p*'s > .181) three out of the four health behavior outcomes: alcohol, smoking, and physical activity. Although the overall models predicting alcohol use, $F(6, 201) = 2.631$, $p = .018$, and physical activity, $F(6, 201) = 2.629$, $p = .018$, were both statistically significant, social support was not significantly associated with either alcohol use or physical activity. The addition of social support accounted for less than 1% of the variation in both health behavior outcome variables. Lastly, social support was also not significantly associated with smoking and there was no increase in the amount of variance explained, although the overall model was still significant, $F(6, 201) = 4.636$, $p < .001$.

Conversely, social support was uniquely and inversely associated with medication nonadherence ($\beta = -.036$, $p = .005$). As previously mentioned, demographic variables did not significantly predict medication nonadherence in this present sample, accounting for less than 1% of the variance in adherence. When social support was added to the model, the model explained 4% of the variation in medication nonadherence. This change in R^2 was statistically significant, ΔR^2 $F(1,201) = 8.204$, $p = .005$.

Examination of whether social support buffers the associations between sleep disturbance and health behavior outcomes.

To test whether social support moderated the sleep disturbance to health behavior associations, four separate moderation analyses were conducted. Controlling for age, gender, race/ethnicity, education, and income, social support did not moderate any of the associations between sleep disturbance and health behavior outcomes: interaction terms for alcohol ($p =$

.669), smoking ($p = .413$), physical activity ($p = .964$), and medication nonadherence ($p = .369$) were all non-significant. Consistent with previous analyses, the overall models were all statistically significant (p’s $< .01$).

Chapter 4: Discussion

The purpose of the present study was to characterize the associations between sociodemographic factors and sleep disturbance with several key health behaviors among a community sample of patients from an urban and underserved safety-net primary care clinic. These associations were examined in the context of two common risk and protective factors: mental health symptoms and social support. Although the focus in the current study was to examine sleep disturbance as a predictor of health behaviors, undoubtedly the associations between sleep and health behaviors are bidirectional. The present study found support for unique demographic associations for all but one of the examined health behaviors: medication nonadherence. As expected, higher sleep disturbance predicted higher alcohol use, lower physical activity, and lower medication adherence; however, its association changed with the addition of mental health for alcohol use. Notably, sleep disturbance remained a strong and significant predictor of physical activity above and beyond mental health. In addition, both sleep disturbance and mental health were uniquely associated with medication nonadherence. Further, social support predicted higher medication adherence and we found no evidence for the buffering effects of social support in our sleep disturbance—health behaviors associations.

Prior to examining predictors of health behaviors, it is helpful to note the prevalence of health behaviors in this high-risk, understudied safety-net primary care sample. Overall, we found a higher prevalence of adverse health behaviors in this community sample compared to the general population, as we expected and consistent with the literature (e.g., Bjorvatn et al., 2017; Pilowsky & Wu, 2012; Vinson et al., 2010). The percentage of the sample who met criteria for hazardous drinking was 31%, which is higher than the national average (National Institute on Alcohol Abuse and Alcoholism, 2022; Substance Abuse and Mental Health Services

Administration, 2019). Only about one-quarter of the total sample were non-smokers, which is elevated compared to the national trends of (tobacco) smokers (Creamer et al., 2019; Jamal et al., 2018). A large proportion of the sample were considered insufficiently active per the current recommended guidelines by the U.S. Department of Health and Human Services (2008, 2018) and World Health Organization (2021), with about 15% of the sample reporting a lack of physical activity—even walking leisurely (i.e., "light" physical activity). Lastly, medication nonadherence behaviors fell within the moderate range for our patient sample.

Demographic Predictors of Health Behaviors

Alcohol. Men in the current sample were more likely to engage in alcohol use than women and gender remained a significant predictor of alcohol use across all of our models. These findings are in line with longstanding documented trends in the literature (Nolen-Hoeksema, 2004; A. White, 2020). Men are more likely to drink more often and more heavily than women do, are more likely to binge drink and to meet criteria for an alcohol use disorder, as well as have higher rates of alcohol-related hospitalizations than women (Centers for Disease Control and Prevention, 2022b). Our findings support the general literature and extend findings by demonstrating that these gender associations hold true for an at-risk safety net primary care sample.

Smoking. Age, race/ethnicity, and education were associated with more smoking, with those who are younger, have a lower education, and identify as white or Asian reporting to engage in more smoking. As previously mentioned, smoking rates in our sample (74.5%) were remarkably higher than the general population (13.7%). Previous research has documented that smoking rates can climb to nearly as high as 50% in some disadvantaged groups, including those who are uninsured and low-educated (Perkett et al., 2017), which is in the same direction although lower than our findings. Interestingly, members of underrepresented minority groups in our sample were not found to be engaging in more smoking as we originally hypothesized. Instead, the other racial/ethnic category, which consisted of white, Asian, and Pacific Islander-identifying patients, were smoking more in our sample. In the general U.S. population, smoking prevalence is consistently found to be highest for American Indian and Alaska Native individuals (Centers for Disease Control and Prevention, 2022a; Wang et al., 2018). According to the CDC (2022a), Black adults are the second highest smokers (14.4%) in the U.S., followed by white adults (13.3%). However, a 2018 report published on tobacco use in the U.S. found smoking prevalence to be higher among white (15.2%) adults compared to Black adults (14.9%; Wang et al., 2018). Although these differences (0.3%) are relatively minor, it is possible that these prevalence rates are dynamic and may be shifting within these two racial groups across time. Similarly, a large nationally-representative population-level study on smoking trends between 1992 and 2018 reported that non-Hispanic whites had the highest cigarette consumption compared to African American and Latinos across education level and over time (Nguyen-Grozavu et al., 2020). When contextualizing the current study's findings, it is worth questioning and considering why white patients from this specific safety-net clinic are smoking more (e.g., perhaps white safety-net patients are coming from more rural areas and/or are lower income compared to the Black patients at this clinic?).

Physical Activity. As hypothesized, younger adults and men reported engaging in more physical activity in our sample. This is in line with the substantial body of evidence that indicates that men tend to be more physically active then women (Carlson et al., 2015; U.S. Department of Health and Human Services, 2015), and that physical activity levels tend to decrease with age (Buchman et al., 2014; U.S. Department of Health and Human Services, 2008, 2015, 2018). It is well established that an important group of determinants of physical activity are socioeconomic factors, ranging from age and gender to health insurance status and BMI category (e.g., see Carlson et al., 2015). As our patient sample was fairly homogeneous with regard to race and socioeconomic class (e.g., income and education levels), it is possible that greater variability of these demographic factors would have impacted their associations with physical activity. Important contextual considerations to keep in mind regarding physical activity for this underserved sample are further discussed below.

Medication nonadherence. Interestingly, no demographic factors emerged as significant predictors of medication nonadherence in our sample. As noted previously, medication adherence is conceptualized as a multidimensional construct that is affected by (1) socioeconomic factors, (2) therapy related factors, (3) factors associated with the healthcare team and system, (4) disease-related factors and (5) patient-related factors per the WHO (2003). In broader terms, these factors fall into the categories of patient-related factors, physician-related factors, and larger healthcare system related factors (Brown & Bussell, 2011). The lack of an association with sociodemographic factors and medication nonadherence could reflect the relatively universally lower socioeconomic status of this safety-net sample which made socioeconomic status a less relevant predictor. Additionally, perhaps factors outside of socioeconomic characteristics, such as mistrust of medical providers or ineffective communication between the primary care provider and patient, may play a bigger role in nonadherence for this unique and high-risk patient sample.

Sleep Disturbance and Health Behaviors

The major focus of this study was to examine the association between sleep disturbance and health behaviors by first examining the predictive power of sleep disturbance and then by controlling for mental health. Sleep disturbance was associated with all but one health behaviors: smoking.

Alcohol use and sleep disturbance. The pattern of results observed between sleep disturbance, mental health, and alcohol use is noteworthy. When sleep was uniquely entered into the model without mental health, greater sleep disturbance significantly predicted higher alcohol use. This result is consistent with prior research in a general community sample (Chakravorty et al., 2016; Ebrahim et al., 2013) and is a more novel finding within a safety-net population. However, sleep disturbance was no longer significantly associated with alcohol use when entered into the model with mental health symptoms (which also became non-significant). One potential explanation for this nullification of effects is the "suppressor effect," which occurs when a suppressor variable changes the original relationship between a predictor and the outcome when added to the model, either by making it stronger, weaker, or no longer significant. Although sleep disturbance and mental health were unique predictors in separate univariate models, the shared variance between these two constructs appears to have diluted their individual unique effects on alcohol use when in the same model, thus changing their unique associations. Although we attempted to control for some of their shared variance by preemptively removing the sleep-related item in the PHQ-9, as well as carefully assessing for multicollinearity, it is possible that there is still some lingering multicollinearity among our variables which may have impacted the results. Interestingly, we did not see these suppressor effects in relation to other health behaviors. Importantly, the associations between sleep, mental health, and alcohol use are likely bidirectional and comorbid. Sleep disruption is highly comorbid with many, if not most, psychiatric disorders; in fact, sleep disruption has been linked to the development, progression, and maintenance of both anxiety and mood disorders (American Psychiatric Association, 2013;

Benca et al., 1992; Harvey et al., 2011; Neckelmann et al., 2007). While our findings did not support our hypothesis, it is nevertheless evident that there are links between sleep disturbance, mood, and alcohol use; the processes and mechanisms by which they are associated in the present sample warrants further investigation. The associations between these three variables is perhaps more complex than can be captured by the current analyses.

Smoking and sleep disturbance. In contrast to the study's hypotheses, sleep disturbance was not associated with smoking. These findings are discordant with the substantial evidence that points to a strong (bidirectional) link between sleep and smoking (Grandner, 2019; Patterson et al., 2016, 2019; Peltier et al., 2017). As smoking was assessed with a single-item question assessing smoking behavior, future work should use a more comprehensive and nuanced measurement of smoking. Additionally, the smoking prevalence in our sample was disproportionately high—though seemingly normally distributed—compared to the general population. Potentially with greater variability in smoking behavior we may have detected some links between varying levels of smoking and both sleep disturbance and mental health.

Physical activity and sleep disturbance. Our findings on the association between sleep disturbance and physical activity were fully aligned with our hypotheses. First, when contextualizing the physical activity findings, it is fundamental to keep in mind the characteristics of this sample. Namely, the majority of the present study's sample are Black and living in poverty, both of which are found to be disproportionally associated with decreased odds of partaking in sufficient physical activity (e.g., Bantham et al., 2021; Hawes et al., 2019). Underserved groups, including racial/ethnic minorities and low-income individuals, face unique community, societal, institutional, and environmental barriers (Bantham et al., 2021) that may prevent them from achieving adequate levels of physical activity (e.g., lack of access to parks or recreational activities, air pollution, unsafe conditions, poor quality sidewalks and neighborhood walkability, and becoming targets for discrimination). Accordingly, less than 30% of the overall sample is meeting the recommended physical activity guidelines per the U.S. Department of Health (2008, 2018) and World Health Organization (2021), and approximately 15% of the sample is considered inactive. These results are consistent with previous research which found that 83% of primary care patients are considered insufficiently active (Glenn et al., 2018).

Our finding that lower sleep disturbance was significantly associated with higher physical activity—above and beyond mental health—is notable for several reasons. As sleep and mental health often get grouped together or viewed in tandem, we intentionally focused on teasing apart sleep disturbance from mental health in order to examine their unique, distinct associations. By doing so, sleep disturbance emerged as not only an important predictor of higher physical activity, but it also remained a strong predictor after accounting for mental health, which was not significantly associated with physical activity. These patterns of findings raise an important question regarding *why* sleep rather than mental health was associated with physical activity for our sample. As considerable evidence already exists focusing on the physical activity to sleep association, the present study (and next section) extends the general literature by exploring the alternate directionality of this association: sleep—physical activity. Importantly, however, this association is bidirectional with higher physical activity also linked to reduced sleep difficulties and improved sleep quality (Kline, 2014; Kline et al., 2013; Kredlow et al., 2015; Spörndly-Nees et al., 2017; P.-Y. Yang et al., 2012).

Sleep is a critically important behavior and essential element of health, supporting and contributing to a wide range of systems as well as diverse aspects of health and functioning, including cognition, mood, and physical health. Broadly, sleep has a multifaceted impact on several major cognitive domains and processes (Deak & Stickgold, 2010; Walker, 2009) that are necessary for engaging in health behaviors including physical activity. For example, sleep loss has been linked to impaired executive functioning and cognitive control (e.g., decision-making; attention; planning), as well as reduced motivation (e.g., see Grandner, 2019). Sleep influences cognitive tasks such as motivation and planning, which are essential in engaging in physical activity and other health behaviors. Deficits in decision-making, planning, judgment, and motivation can lead to impaired ability to engage in physical activity (Greer et al., 2013; Killgore et al., 2006). Beyond cognitive impacts, sleep is profoundly essential to our physical health. Sleep serves as an important regulator of numerous biological and physiological factors, including the maintenance of vital physiological functions and homeostasis, as well as by promoting the development of the central nervous system and physical recovery (Dáttilo et al., 2011; Grandner, 2019; Tufik et al., 2009). Sleep contributes an important role in the process of muscle recovery, mainly due to its effect on hormone secretion, which is fundamental for the necessary healing and repair our bodies need to be physically active and to gain muscle mass and strength (Dáttilo et al., 2011, 2020). In fact, it is well-established that skeletal muscle recovers and grows during sleep, and that sleep deprivation causes loss of muscle mass and reduces muscle regeneration (e.g., see Dáttilo et al., 2020). Notably, these are benefits that only sleep can provide, which further highlight the unique contributions of sleep's link to physical activity above and beyond mental health. Further, and perhaps more obvious, healthy sleepers awaken the next day with sufficient energy to engage in activities such as exercise (Holfeld & Ruthig, 2014), whereas poor sleep is linked to increased fatigue, as well as reduced energy, alertness, and vigor (Bromley et al., 2012; Dinges et al., 1997; Grandner, 2019). Taken together, sleep's unique restorative properties have clear and strong ties and benefits to processes that are crucial for a physically active lifestyle, ranging from increased energy to muscle repair and healing.

Additionally, there is recent emerging evidence that *sleepiness* may be a potential mechanism behind the detrimental effect of poor sleep on health (Axelsson et al., 2020). Sleepiness is associated with both the preservation and utilization of resources towards sleeping, as a primary function of sleepiness is to prepare to sleep, and a decreased inclination and motivation towards engaging in other competing behaviors like physical activity. According to this theoretical framework, sleepiness helps organize behaviors toward the specific goal of sleep-preparatory behaviors (e.g., resting; staying in bed), in competition with other needs and daily activities. Indeed, sleep loss and self-reported sleepiness also reduces willingness to engage in physical activities and social behavior (Axelsson et al., 2020). Consequently, sleepiness may be a central mechanism behind how insufficient and disturbed sleep increase the risk for a sedentary lifestyle. In sum, our findings provide initial evidence that suggests sleep may be a more important link for physical activity than mental health in this sample. These findings also extend the literature by focusing on a unique, underserved, and at-risk community sample.

Medication nonadherence and sleep disturbance. The findings from the current study add to the literature supporting the important roles of sleep (and mental health) for medication adherence. Specifically, our findings highlight the important links between healthy sleep and mental health for medication adherence behaviors in a predominantly low-income, diverse patient sample. Patients with lower sleep disturbance and mental health symptomatology reported higher medication adherence across a variety of general adherence activities, such as complying with medication prescriptions even when feeling better or in the presence of side effects. These findings align with previous studies that suggest sleep disturbance is strongly associated with decreased medication adherence, with one study in particular revealing that sleep disturbance was reported by nearly 75% of low adherers in a sample of adults living with HIV (Gay et al., 2011). As previously mentioned, the bulk of the existing literature on medication adherence has focused on very specific clinical populations and treatment regimens, such as CPAP adherence in obstructive sleep apnea (Platt et al., 2010) or adherence to treatment regimens for chronic illnesses such as HIV (Malcolm et al., 2003) and diabetes (Chasens et al., 2013). Though these studies are critically important and provide important empirical insight into what adherence looks like for these groups and regimens, there is a much smaller body of literature that has examined medication adherence as a broader construct/health behavior. Additionally, research examining medication adherence in high-risk safety-net primary care patients is even more limited.

Furthermore, our finding that no demographic factors were associated with medication adherence in our sample, yet both sleep disturbance and mental health are unique predictors, further highlights the important roles of sleep and mental health for this crucial health behavior. One potential explanation is that sleep disturbance can inhibit daytime functioning and common symptoms of poor sleep (e.g., daytime sleepiness, fatigue, and difficulty concentrating) can be pathways to poor adherence behaviors (Gay et al., 2011; Thase, 1999). A prior study conducted on HIV-infected patients identified both sleep and depression as barriers to medication adherence, and highlighted their bidirectional influences on patients' adherence behaviors (K. D. Phillips et al., 2005). Patients who endorsed more severe depression were more likely to fall asleep through dose time and perceive that they had too many medications to take than those with mild depressive symptoms; on the other hand, poor sleepers were more likely to forget medications, have difficulty with taking medications at specified times, and run out of pills than healthy sleepers. Given that sleep disturbance and symptoms of depression and anxiety often co-occur, future research should further explore their relations to adherence. In the current study, both sleep disturbance and mental health symptoms remained unique predictors in the same model. These findings, and the known bidirectional links between sleep, mental health, and adherence, suggest both are crucial to further investigate and provide multiple avenues to promote adherence. Understanding the mechanisms underlying these associations is also an important and a needed area for future research (e.g., Does sleep disturbance impair executing functioning abilities required for adherence? Does sleep disturbance exacerbate poor mood and motivation needed to adhere?).

Social Support

Contrary to our hypotheses, social support was only associated with one health behavior outcome, medication nonadherence, whereby greater social support was found to predict higher medication adherence. Additionally, and contrary to what we expected and what the general literature has found strong evidence for, social support did not moderate the indirect effects of sleep disturbance to any of the examined health behaviors in our sample. Social support was correlated with lower sleep disturbance, so perhaps social support is protective against sleep disturbance in ways other than buffering the association between sleep and health behaviors.

Nonetheless, social support was a relevant predictor of medication adherence, as we expected. Prior research suggests that social support is strongly associated with enhanced adherence. In fact, social support has even been found to be a more robust predictor of adherence than depression or stress (Shallcross et al., 2015). Notably, most of the existing research is focused on very specific clinical populations and adherence regimens, such as patients with HIV (Gonzalez et al., 2004), hypertension (Shahin et al., 2021), Type 2 diabetes mellitus (Gu et al., 2017), epilepsy (Shallcross et al., 2015), and psychosis (Rabinovitch et al., 2013), as well as specific age groups—older adults (Voils et al., 2005). Far fewer studies have examined the relations between social support and adherence in socioeconomically disadvantaged and racially/ethnically minority groups—this area of investigation is a critical need as medication adherence rates are disproportionately lower among patients with lower socioeconomic status and a racially/ethnically minority background (e.g., see McQuaid & Landier, 2018). Our findings provide additional support for the link between social support and medication adherence, as well as expand the existing evidence to include safety-net primary care patients. As we did not exclusively target a specific condition or treatment regimen as many researchers have done, our findings speak to a more general and broader link between higher social support and higher medication adherence behaviors.

The precise mechanism(s) by which social support may influence medication adherence indirectly and directly is quite complex and not yet fully understood. Additionally, social support and medication adherence are likely bidirectionally associated whereby greater medication adherence could promote greater motivation and opportunity for mobilizing social support. Broadly, individuals with greater social support have higher numbers of people in their social networks to leverage for support with their medication regimen(s). Potential mechanisms speaking to the social support—medication adherence pathway include social support's effect on health by increasing self-efficacy, buffering stress and depressed mood, and enhancing quality of life (DiMatteo, 2004a). According to the Social Cognitive Theory, social support can engender self-efficacy, which in turn can enhance health behaviors such as medication adherence (Bandura, 2004). Greater social support is also associated with less depressive symptomatology, positive states of mind, and better quality of life (Gonzalez et al., 2004); perhaps when our mood and quality of life is increased, we are more motivated and invested to take care of ourselves. A study conducted on HIV-infected adults illustrated that excellent adherers for antiretroviral therapy were not actively depressed and received substantial social support compared to less adherent patients; they were also more likely to be open about disclosing their HIV status to friends and family in order to mobilize their support systems (Malcolm et al., 2003). Among older adults, social support can help patients remain active in their healthcare when faced with physical and economic difficulties (T. Miller & DiMatteo, 2013). Furthermore, social support is also particularly essential for helping patients with limited health literacy with medication adherence; without having a trusted confidant, limited-literacy patients reported they were more reluctant to ask their pharmacist for the help needed to take their medicines correctly (Johnson et al., 2010). Further empirical evidence is needed to better understand and address the mechanisms by which social support works to directly influence adherence and other health outcomes, particularly for low-income, racially and ethnically diverse individuals.

In addition to assessing general social support, there are various types of social support linked to enhanced adherence including instrumental support, such as reminding the patient to take their medication and helping them take their medication correctly, as well as emotional support, such as providing empathy and helping them cope with their condition. Although social support was examined as a global total score in the present study, we conducted additional analyses using the ISEL-12 measure's subscales (i.e., appraisal, belonging, and tangible support) in order to assess whether specific types of social support may be differentially associated with our variables of interest. Though this additional step did not change any of our findings, it may be worthwhile to consider what types of social support might be particularly important for different health behaviors in future research.

Several factors may explain the lack of association between social support and the other examined health behaviors, as well as the lack of moderating effects. It is possible that the social support measure used in the present study is not adequately capturing the lived experiences of this population in regards to their social support. For example, the first item of the ISEL-12 questionnaire asks: “If I wanted to go on a trip for a day (e.g., to the mountains, beach, or country), I would have a hard time finding someone to go with me.” As the majority of this sample is low-income, uninsured, and living in or below the Federal poverty line, traveling on a trip for a day is likely not feasible or accessible for this sample (e.g., consider access to transportation, childcare). A more culturally-sensitive tool that takes contextual factors into consideration would be better able to appropriately assess for social support in this sample. Perhaps social support looks different for more vulnerable, undeserved communities. Conversely, perhaps these patients are unable to tap into their social support because they have more imminent threats to their health and safety (e.g., lack of stable housing). According to Maslow’s hierarchy of needs (1943), needs lower down in the hierarchy (e.g., physiological needs including sleep, food, and shelter) must be satisfied before attending to higher needs (e.g., love and belonging). The lack of evidence for social support’s buffering role raises questions about whether social support is as relevant of a factor for certain adverse health behaviors for this sample. Further, perhaps social support may not be sufficient to modify the potential detrimental impact of sleep disturbance on health behavior outcomes that patients in this safety-net primary care sample may be experiencing. It is worthwhile for future work to investigate what other factor or process may have accounted for this link.

Implications

Several noteworthy implications can be derived from the present study. First, the present study highlights the strong links between sleep disturbance and several critical health behaviors (i.e., alcohol use, physical activity, and medication nonadherence). In an at-risk, underserved patient population, sleep shows potential for investigation as a target for health promotion and health behavior change. As sleep and mental health often get grouped together, the present study also provides important insight into the unique, distinct associations of sleep and mental health with health behaviors. For some health behaviors (e.g., alcohol use), sleep disturbance and mental health were correlated and suppressed their own unique significant effects when examined together. For other health behaviors (e.g., physical activity and medication nonadherence), sleep disturbance either stood alone or with mental health as a significant, unique predictor of health behavior.

Sleep is an important pillar and determinant of overall health yet disparities in sleep continue to persist. Sleep disturbances are differentially experienced according to race/ethnicity, education, poverty, access to private insurance, and food insecurity, among others (Grandner et al., 2013). Evidence suggests that marginalized groups, particularly racial/ethnic minorities and individuals with low socioeconomic status, have difficulty achieving healthy sleep (e.g., see Grandner et al., 2016). Understanding the complex factors of sleep using a social-ecological framework is an important step for better understanding and reducing health inequities. Future studies will be needed to provide a more comprehensive picture of how sleep health is differentially experienced among underserved groups, including how sleep-related practices, beliefs, and attitudes may differ across diverse groups.

Clinical Implications

Continued screening for sleep, mental health, and health behaviors are warranted for early detection efforts, and psychoeducation should be provided on the robust links between sleep and health behaviors as an initial step. As the links between sleep and health behaviors are bidirectional, treatment of either problem has the potential to impact the other. Although time is always at a premium, the findings strengthen the need for clinicians to be aware of the importance of sleep, discuss steps towards achieving healthy sleep, and incorporate sleep assessments as part of any lifestyle or preventative care assessment. Assessing and promoting healthy sleep in a culturally-sensitive way (e.g., using culturally-adapted CBT-I treatments appropriate for underserved populations) is essential for the reasons discussed above. Recognizing and acknowledging how the patients' structural, social, and environmental context may be challenges to achieving healthy sleep is important and should be an increased practice. Notably, more work is needed to further develop and validate CBT-I interventions for underserved populations. Moreover, treatment of sleep difficulties can be seen as a "gateway" intervention, as they are less stigmatized than mental health treatments, which is important to keep in mind for this underserved population whom already disproportionately faces stigma and other barriers for accessing care.

Awareness of the unique risk factors associated with different health behaviors is also warranted and the identification of these factors should be a priority at intake. For example, it is important for healthcare professionals to note potential increased risk for insufficient physical activity for women and older adults, as well as the strong link between poor sleep quality and a more sedentary lifestyle. Equally of importance is the awareness and promotion of protective factors such as social support. Findings also shed light on how risk and protective factors may not be uniform for all health behaviors. For example, social support was associated with adherence but not any of the other health behaviors in our sample. Targeting social support in screening and intervention approaches in racially/ethnically diverse and low-income patients may be most important for medication adherence versus other health behaviors such as smoking. More research is needed to replicate and understand these differences. Nonetheless, using a "one-size-fits-all" approach towards health behavior change may not be the most effective or appropriate as each health behavior has its own unique factors associated with it.

The Need for Integrated Behavioral Healthcare

The present study further highlights the long-existing and continued growing need for integrated care in primary care settings. The primary care setting is the entry point for the vast majority of patients with chronic conditions who become dependent on our healthcare system for long term care (Sadock et al., 2014). Notably, undeserved low-income and racial/ethnic minority populations often seek services through primary care, and are more likely to seek help and receive care in primary care as opposed to specialty care (Institute of Medicine, 2000; U.S. Department of Health and Human Services, 2001; VanderWielen et al., 2015; World Health Organization, 2008). For an array of reasons, PCPS are not well equipped to adequately assess and address behavioral health concerns such as disturbed sleep and mental health concerns.

Inadequate sleep training among PCPs. Although certain sleep disorders such as sleep apnea and narcolepsy are typically referred to sleep medicine specialists for treatment, general sleep disturbances and insomnia are often neglected or dealt with in the context of primary care (Grandner & Chakravorty, 2017). This approach is problematic for a variety of reasons. PCPs are increasingly being thrust into the role of treating behavioral health concerns; however, they often lack training in the screening, assessment, and treatment of sleep disturbances and disorders such as insomnia. On average only about one hour of total teaching time is allocated to sleep and its disorders to medical students, with less than 4% of medical schools offering four or more hours of didactic teaching on sleep. Among the major obstacles identified were a lack of curriculum time, the absence of qualified faculty, and the need for additional clinical and education resources; more than two-thirds of respondents reported feeling that their education and training is inadequate in this area (Rosen et al., 1993). Some medical schools (ranging from 18% to nearly 30%) do not provide any formal instruction on sleep-related topics (Faruqui et al., 2011; Mindell et al., 1994). Unfortunately, yet unsurprisingly, this lack of training translates to deficits in recognition and intervention. In a sample of over 600 PCPs, fewer than half endorsed feeling confident in screening (46%), evaluating (34%), or treating (25%) sleep problems (Owens, 2001). Many physicians report wanting more education and training in the management of sleep disturbances and disorders, as well as more clarity in current guidelines for providing and/or referring patients to appropriate care (Cheung et al., 2014; Davy et al., 2013); however, most physicians (80%) also report being overextended or at full capacity (Cheung et al., 2014). Importantly, these sentiments occur within a context and system in which a steadily increasing number of patients continue to present to primary care for sleep complaints.

Missed opportunities for intervention. Overall, sleep disturbances are frequently not discussed or brought up at all, mishandled in its treatment and care, or often just simply missed in primary care visits (e.g., see Ulmer et al., 2017). When they do address disturbed sleep, PCPs tend to use a “stepped” treatment approach which consists of sleep hygiene education followed by pharmacotherapy. For example, Ulmer and colleagues (2017) found that PCPs perceived sleep hygiene as the most available treatment option for insomnia, providing sleep hygiene education to their patients more than any other approach. This approach is not only ineffective

(Irish et al., 2015) but it also directly contrasts the strong, empirically-supported guidelines that CBT-I should serve as the first-line treatment for insomnia, as recommended by the American Academy of Sleep Medicine (Morgenthaler et al., 2006), the Society of Behavioral Sleep Medicine (Schmitz, 2016), the National Institutes of Health (2005), and the American College of Physicians (Qaseem et al., 2016). Also common among PCPs is offering pharmacotherapy via hypnotic medications, antidepressants, or through adjusting the patient's medication(s) that "may" be contributing to their insomnia (Ulmer et al., 2017). These suboptimal strategies may not be appropriate and in some cases may be hazardous, potentially leading to additional problems or future complications. Further, evidence also suggests that PCPs spend an average of less than 1% of their face-to-face time with patients discussing preventative health care (e.g., screening, lifestyle counseling; Gutierrez et al., 2015). Even when these topics are addressed, PCPs often provide a "quick" statement on risk and seldom provide patients with practical education, support, and tools that are needed to actively help promote health behavior change (Bartsch et al., 2016; Keto et al., 2015; Sherman & Hooker, 2020).

Moving towards a solution. The reasons for these shortcomings and failed opportunities to assess and effectively intervene with providing health behavior promotion are systematic and complex and go beyond the scope of the current study. Nevertheless, it is clear that the current system can be improved by continuing to move towards integration of behavioral health services. As integrated clinics serve as a "one stop shop" for patients to seek and receive care for their various multifaceted needs (e.g., ranging from medical care to behavioral health and social work services), providers in these settings are in a unique position to foster interdisciplinary collaborative care and work alongside behavioral health specialists to target sleep and other health behaviors that are missed or inadequately treated. Behavioral health specialists, including psychologists, embedded in primary care settings have the time protected to comprehensively treat these concerns, as well as the skillset needed to effectively treat a diverse range of behavioral health (including sleep) concerns. Psychologists are more equipped to intervene on sleep disturbances and provide culturally-responsive, evidence-based interventions that are individually tailored for each unique patient. Therefore, the present study echoes the existing calls to greatly increase the presence of psychologists in primary care (e.g., see American Psychological Association, 2009). The increased presence of available on-staff psychologists who collaborate with the medical team and, importantly, are *utilized* by them is a crucial need that should be prioritized. Medical providers can increase warm hand-offs and referrals to help get patients where they need to be for treatment and care. Taken together, integrated behavioral healthcare provides a unique opportunity to fulfill a critical need by meeting patients where they are (O'Loughlin et al., 2019), and appears to be the most efficient way to reduce barriers, increase access, and address patient needs (B. F. Miller et al., 2009). Efforts towards improving and expanding integrated services, particularly for underserved communities, are a critical need and should remain a priority.

Limitations, Strengths, and Future Directions

The current study has several limitations which should be considered when interpreting its findings, and as a result, directions for future research. First is related to the cross-sectional design of the study, as we were unable to assess causality or directionality among our variables of interest by the current analyses. For example, perhaps patients who are nonadherent to their medication regimens are sleeping worse and, as a result, feeling more depressed and/or anxious. Longitudinal investigations and prospective designs are a critical next step for future research to assess causality, temporality, and directionality in order to identify the unique and complimentary contributions of these variables, as well as to investigate whether the cross-sectional findings hold over time. Additionally, the study relied exclusively on self-report measures. Various potential threats to internal validity are also introduced with our design, including recall bias and fatigue due to the quantity of measures.

Incorporating objective measures of sleep (e.g., actigraphy) and more comprehensive global assessments of sleep (e.g., PSQI; sleep diaries) would complement existing self-reported sleep and enrich the measurement of sleep. More thorough and comprehensive assessments that include questions about racism, discrimination, and unmet needs (e.g., with respect to housing; employment), among other social factors, are a major need as we move towards better understanding the structural, social, and environmental contexts that influence sleep. Similarly, measurement of physical activity via diaries or electronic means would provide a more accurate and comprehensive view of activity levels than multiple-choice retrospective recall estimates. Undoubtedly, introducing comprehensive and longitudinal assessments presents its own challenges in regards to time and resources. There is much need to find an appropriate and reasonable balance between such assessments and their feasibility for this overburdened population. Future longitudinal research should also consider assessing medication adherence by combining multiple measures of adherence, such as electric monitoring and self-report, to increase validity and reliability. A deeper understanding into the complex barriers and factors (e.g., patient, provider, cultural, historical, and healthcare system factors) that collectively play a role in adherence behaviors is warranted. Further, as discussed previously, our measurement of social support may not have been the most appropriate for our sample. As social support can look different across cultures and class, it is critical for measures to capture social support appropriately and accurately for each unique sample.

Despite its limitations, the present study contributes to and expands the literature in a meaningful way. First and foremost, we focused on an underserved sample that has historically been excluded or difficult to reach (e.g., with respect to research and clinical care). As a result, characterization of the prevalence and associations between critically important health behaviors, ranging from sleep to physical activity, is a meaningful addition to the health psychology literature. We also focused on multiple health behaviors, further enriching our understanding of the similarities and differences across health behaviors in this diverse patient sample. Compared to alcohol use, tobacco, and physical activity, medication adherence has been relatively less studied and thus our findings underscore the increased need to continue exploring this health behavior. Although we cannot determine causality, the current study extends the literature by focusing on sleep's association with health behaviors, whereas the bulk of the literature has focused on the alternate directionality (e.g., alcohol use impacting sleep). Lastly, recognizing the strong empirical evidence for social support on health outcomes, we aimed to incorporate a strengths-based approach by also examining social support, a key protective factor.

Conclusions

Primary care settings show elevated rates of smoking, alcohol use, low physical activity, and disturbed sleep—each of which have clear, established links with greater all-cause mortality and have each been identified as a major public health problem. The current study enhances our understanding of the important links between disturbed sleep and several adverse health behaviors (i.e., alcohol use, physical inactivity, and medication nonadherence) in an understudied and underserved community patient sample. Underserved populations, including racial/ethnic minorities and individuals with low socioeconomic status, are disproportionately at high risk for poor health outcomes and adverse health behaviors. As such, understanding the associations between these modifiable and interrelated health behaviors is an important step towards reducing their prevalence and health inequities at large. Sleep shows potential as a critical target for health promotion and health behavior change. Our findings have important clinical implications by indicating target areas for health promotion, at-risk identification, and intervention efforts. Continued research efforts are needed to further explore the bidirectional associations among sleep, health behaviors, and mental health to work towards health promotion.

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