INDOOR PLANTS, BURNOUT MITIGATION AND THE WELLNESS OF HEALTHCARE WORKERS

A Thesis

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Master of Science in Horticulture

by

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ABSTRACT

Previous research has found that indoor plants may improve aspects of occupational wellness in office workers. Healthcare workers, particularly those working in primary care settings, report high rates of burnout. However, limited evidence exists regarding the effect of indoor plants on healthcare worker wellness or burnout. In this mixed-methods, randomized control pilot study, four primary care clinics were studied to evaluate the impact of indoor plants on burnout rates. Potted foliage plants were placed in treatment clinics and remained for two months. Surveys were administered to evaluate rates of burnout and nature connectedness of workers in treatment and control groups before, during, and at the end of the treatment period. Semi-structured qualitative interviews were conducted to elucidate participant perceptions of the role of indoor plants and nature exposure in occupational wellness. Quantitative data showed trends toward reduced burnout over time in the treatment group, particularly among providers and those with low nature relatedness. Interviews found that participants associated indoor plants and outdoor nature exposure with wellness indicators and burnout modifiers, including enhanced mood and physical wellbeing, cognitive restoration, mindfulness, and cohesive workspaces. The addition of indoor plants appeared to enhance workplace wellness and possibly reduce burnout among medical professionals in this study. Healthcare organizations should consider the use of indoor plants as valuable additions to the built environment of outpatient healthcare facilities to improve occupational wellness and reduce burnout among employees.

BIOGRAPHICAL SKETCH

Carol Elisabeth Green studied neurobiology and English literature at Harvard (2009), creative writing at the University of Southern Maine (2014), and medicine at the University of Rochester School of Medicine and Dentistry (2018). She has worked as a clinical researcher, a greenspace equity and food systems advocate, and a freelance journalist. The central theme of her explorations in scientific research, creative writing, and personal inquiry is the ways in which humans engage and build relationships with the more-than-human world.

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INTRODUCTION

Despite the social upheaval caused by the COVID-19 pandemic, or perhaps because of it, applications to U.S. medical schools hit record highs in the 2021-2022 academic year, a nearly 18% increase from the year before (Boyle, 2022). This may be good news for current medical professionals, since the nation is facing widespread shortages of physicians and nurses. A survey of nearly 600 U.S. healthcare leaders found that 88% of respondents reported nursing shortages at their institutions, and it is predicted that, by 2030, the U.S. will have a deficit of 139,000 physicians (Shanafelt and Kuriakose, 2023; Murthy, 2022).

Clinician shortages are partly attributable to burnout, a phenomenon that is upsetting many professions, but which has hit healthcare particularly harshly since the start of the COVID-19 pandemic. Although prior to the pandemic, the National Academy of Medicine claimed that healthcare faced a crisis of burnout, between 2020 and 2021, physician burnout rates nearly doubled, surging from 38% to 63% (Murthy, 2022; American Medical Association, 2023). Other professions within medicine, including nursing and nursing assistants, face similarly high burnout trends (Murthy, 2022). Besides contributing to a national shortage of healthcare workers, burnout can compromise high-quality care, potentially reducing patient satisfaction and threatening patient safety (Abraham et al, 2019; Han et al, 2019; De Hert, 2020; Panagioti et al, 2018). Burnout is also a large cost for the health system: a 2019 study estimated that $4.6 billion is lost in the U.S. health system annually due to reduced hours and turnover of physicians alone (Han et al, 2019).

Besides system-wide impacts, burnout can have profoundly negative consequences on individual healthcare professionals, increasing the risk of anxiety, depression, substance abuse, and problems in personal relationships, including divorce (De Hert, 2020). In 2022, President Biden signed the Dr. Lorna Breen Health Care Provider Protection Act, an act named after an emergency medicine specialist who took her life during the first wave of the COVID-19 pandemic, which promotes increased awareness of and resources for mental health concerns among providers (Wild, 2022). Despite this act, burnout remains a significant concern in healthcare today.

Much research has been conducted to ascertain potential causes of burnout. Organizational and system-wide factors play a notable role. For instance, higher acuity work environments (e.g., ICUs or emergency rooms) and longer shifts for nurses increase burnout risk, while in primary care, burnout is associated with dissatisfaction with workplace resources, less effective communication between colleagues, and a lower sense of workplace cohesiveness (Buckley et al, 2020; Abraham et al, 2019). Higher-than-recommended patient panels (that is, the number of patients assigned to a particular provider), increased staff turnover, a full-time (vs. part-time) schedule, and working in environments perceived as chaotic or unpredictable are also predictors of burnout (Abraham et al, 2019). Primary care providers in health system-owned practices or federally qualified health centers are more likely to feel burnt out than those working in physician-owned practices (Abraham et al, 2019). Individual practice, system-wide and national initiatives to modify payment models and policies, then, may aid in burnout reduction (Brigham 2018; Abraham et al, 2019). Other notable but perhaps less easily modifiable contributors to burnout are individual based, including age and experience level (which tend to exhibit an inverse correlation with burnout) and personality traits such as neuroticism and low agreeableness (positively correlated with burnout) (Buckley et al, 2020; Abraham et al, 2019). In contrast, a sense of medicine as a professional calling is associated with lower risk of burnout (Abraham et al, 2019).

Because national and institutional policies may be complicated and slow to enact, while individual interventions to mitigate personality traits may be time consuming for workers who are already stressed by their workload, the question arises: are there alternative ways to alleviate burnout among healthcare workers? A potentially high reward, low risk intervention is modification to the built environment. The effects of the built environment on patient and worker wellbeing have historically been overlooked in healthcare design (Dijikstra, 2008). However, extensive evidence suggests that the built environment can impact a range of physical and psychological health measures through ambient factors (such as lighting and noise levels), architectural features (such as room size and window views), and interior design elements (such as furniture layout and artwork) (Rashid and Zimring, 2008). For instance, higher average noise levels in working areas for nurses result in higher heart rates, reported stress and

annoyance, while working close to a window has been associated with greater job contentment, and poor lighting in offices can increase the risk of headaches, eyestrain, and low worker morale (Rashid and Zimring, 2008).

A promising way to positively modify the built environment is through incorporation of biophilic elements. Biophilic design is the process of adding natural or natural-appearing elements into built spaces to enhance a sense of connectivity to the natural world for occupants. It is an outgrowth of the biophilia hypothesis, which asserts that humans have an innate, emotionally driven desire to connect with the more-than-human world (Wilson, 1984). Buildings have used biophilic design for much of history. As Kellert et al (2011) observe, builders and artisans often integrated buildings with the natural environment, using local materials and patterns observed in nature within their designs. In modern times, however, as a result of the growing separation of humans from the natural world, many indoor environments are deprived of sufficient natural light, natural views and other forms of contact with the more-than human world, and biophilic design has thus been viewed as novel and innovative (Kellert and Calabrese, 2015; Kellert et al, 2011). Today, integration of biophilic elements, such as natural light, natural materials (e.g. wood), indoor plants, greenery on outdoor facades, water features, animal motifs or animals that can be kept indoors (e.g. in aquariums), and window views of nature, may be used to promote a sense of enhanced connection to the natural world while indoors (Kellert et al, 2011).

Much of research on the health effects of particular biophilic elements has focused on outcomes for patients or people outside the context of the workforce. For instance, a seminal study by landscape architect Roger Ulrich (1984) found that window views of nature reduced hospital length of stay and pain medication use in patients recovering from gallbladder surgery. Subsequent studies have supported the finding of better pain control, as well as reduced blood pressure and fatigue, in hospitalized patients exposed to nature views or indoor plants (Diette et al, 2003; Park and Mattson, 2009). Studies have also found improved response to stressful situations after being exposed to views of nature compared to human-made structures, and reduction of perceived stress among patients when indoor plant are present in hospital rooms (Brown et al, 2013; Dijikstra, 2008). Furthermore, a host of positive mental and physical

health outcomes have been found for people who live close to green spaces, engage in outdoor exercise in natural areas, or participate in indoor or outdoor gardening (e.g., Wilker et al, 2014; Lee et al, 2014; D'Andrea et al, 2008; Howarth et al, 2020).

Natural features may be beneficial for a few reasons. Because humans evolved in natural environments, it may have been evolutionarily advantageous to find nature physically restorative even after experiencing stressful events, such as being chased by a predator (Ulrich, 1993). This evolution may have also selected for brains that process natural views easily, creating a tendency for humans to find natural environments mentally restorative (Wohlwill, 1983; Kaplan, 1993). The latter can be particularly relevant to ergonomics, since workplaces are often crucibles of mental fatigue, resulting in diminishment of attention capacity (Kaplan, 1993). Some researchers suggest that increasing aesthetic attractiveness of indoor spaces using biophilic elements may mediate stress reduction, while others assert that biophilic elements, and their symbolic representation of outdoor natural spaces, evoke a power distinct from aesthetic pleasure (Dijikstra, 2008; Park, 2004). Regardless of the construct theorized, the potential of biophilic design or biophilic elements to positively mediate physical and psychological stress, particularly in the context of workspaces, is a promising avenue of research. It is an important one, too, considering that on average, Americans spend 90% of their time indoors, much of that due to job requirements (United States Environmental Protection Agency, 2021).

Early research on the effects of natural elements in the workplace found that window views were significantly related to job satisfaction among healthcare workers, and that office workers who sat near views of nature reported significantly fewer health symptoms, greater job satisfaction and even life satisfaction (Finnegan and Solomon, 1981; Kaplan, 1993). More recent research has found that workplaces with natural elements can reduce stress and fatigue and improve work performance compared to conventionally designed spaces (Menardo, 2022). Looking at views of nature, even in the form of photographs of green roofs, for 40 seconds can enhance attentive capacity for work-related tasks compared to views without nature (Lee et al, 2015). Greater contact with nature during the workday, including outdoor breaks, window views of nature, natural light and live plants, is associated with reduced

stress, health complaints and sick days, while listening to nature sounds in an office setting is associated with decreases in muscle tension, heart rate, and perceived stress (Largo-Wight et al, 2011; Bjørnstad et al, 2016; Largo-Wight et al, 2016).

Potted plants are a particularly popular and easily accessible biophilic element to add to indoor spaces. The National Gardening Association has estimated that Americans spent more than $2 billion on houseplants and indoor gardening accessories in 2021 (Starbuck, 2022). Many studies detail the health benefits of indoor plants, finding some similarly positive health effects as other forms of biophilic design and interaction with outdoor nature. Across healthcare, academic and other settings, studies have found the presence of indoor plants to contribute to physical wellbeing, such as increased pain tolerance and an enhanced relaxation response (Kim et al, 2018; Lee et al, 2015). They may even reduce the number of sick days taken by employees (Bringlismark et al, 2007). Indoor plants may also be associated with mental health benefits, reducing anxiety, depressive symptoms, self-reported stress and feelings of drowsiness while working (Kahn et al, 2016; Koh et al, 2019; Kim et al, 2018; Genjo et al, 2019) as well as social benefits, such as workplace satisfaction and reduced misbehavior in school settings (Dravigne et al, 2008; Han, 2009). Work-related cognitive benefits may be associated with indoor plants, such as increased speed of task performance and increased attentiveness (Park and Mattson, 2008; Raanaas et al, 2011). Furthermore, restoratively designed spaces, which promote distraction and a sense of distance from everyday tasks (and often include biophilic elements), may reduce workplace cynicism (Bellini et al, 2015). On the other hand, as Bringlismark et al (2009) emphasize, there is a lack of methodological consistency among studies in the field of indoor plants and human health, particularly in terms of plant size, plant density, and exposure period. Furthermore, a study by Thatcher et al (2020) found that laboratory simulations of work environments with plants had a larger impact than in real-world call center settings, suggesting the need for more “in-vivo” ergonomic studies of varied office environments.

Collectively, these findings suggest the potential of indoor plants to mitigate the three primary dimensions of burnout: emotional exhaustion (characterized by a sense of emotional and sometimes physical fatigue), workplace negativism (also known as depersonalization, characterized by cynicism and

low empathy), and low efficacy (characterized by subjective poor performance in work-related tasks) (Maslach and Leiter, 2016; Maslach and Jackson, 1981). The psychologically and physically restorative effects of indoor plants may reduce exhaustion, while improvements in prosocial behavior and cynicism could reduce employees' depersonalization, and inefficacy could be attenuated by improvements in cognitive wellbeing. One potential way in which plants may work to reduce dimensions of burnout is by increasing a sense of work resources. The Job-Demands Resources model of professional stress suggests that when both job resources and demands are high, job motivation among workers remains high despite job strain (Bakker and Demerouti, 2007). Low resources, in contrast, tend to lead to low motivation for workers. As Bellini et al (2007) posit, restorative indoor environments should be considered a job resource, suggesting that the addition of indoor plants could increase motivation in healthcare workers despite the well-known strains of the field.

Although most studies focus on passive interaction with plants, the few that have studied active involvement (e.g., maintenance tasks such as repotting) have found notable benefits, and it has been speculated that mindfulness training in natural environments may be particularly effective at stress reduction (e.g., Lee et al, 2015; Nisbet et al, 2019). Given the harried quality of most healthcare settings, however, interventions that focus on passive exposure, without intentional associated activities such as mindfulness training, seem like an ideal starting point for designers and healthcare professionals interested in positively impacting the work environment. Some healthcare organizations have limited the number of plants allowed in patient rooms because of concerns of nosocomial infection risk. This concem has been largely disproven, except in care settings of immune compromised individuals, although Moslehian et al (2023) suggest that more research is necessary. In most outpatient settings, there is little evidence to suggest that indoor plants could cause physical harm to patients or staff.

In this thesis, I focus on the impact on healthcare worker wellness of indoor plants as biophilic agents. Chapter 1 is a research-informed editorial about how biophilic design could help the burnout crisis. Chapter 2 presents the methodology and results of my primary research on indoor plants and their potential role in mitigation of burnout in primary care outpatient workers. Throughout this introduction

and the two chapters, I hope to present convincing evidence of the potential benefits, particularly on mental wellbeing, of indoor plants in healthcare environments.

CHAPTER 1

How Nature Could Help the Burnout Crisis

Burnout is disrupting medicine. A recent survey of over 12,000 nurses from the American Nurses Foundation found that 47% believed they were burned out or at the early stages of burnout, while another survey of doctors found that 63% had at least one manifestation of burnout (American Nurses Foundation, 2023; Shanafelt et al, 2022). Although the National Academy of Medicine labeled burnout a crisis within American healthcare prior to the COVID-19 pandemic, is estimated that one in five healthcare workers quit their jobs within a year of the pandemic's start (Murthy, 2022; Yong, 2021). The trend has not ceased: surveys of nurses and doctors suggest that about the same fraction intend to leave their current jobs within the next two years (Henry, 2022).

It is cliché to say that the healthcare system needs to be turned inside out to address this professional crisis. Administrative burden and the unavoidable strain of COVID-19 continue to stress an already short-staffed workforce. True transformation of American healthcare will likely take years. In the meantime, we need a prescription—more likely, many of them—to protect healthcare and its workers. But one evidence-based prescription is easy to find: look outdoors, or perhaps to your windowsill. We need to reintroduce the natural world to medicine.[1]

Western medicine and the natural world have richly entwined histories. "Open air" approaches to treating disease were popular in 19th and early 20th century Europe, built on the idea that recovery benefited from the fresh air of the countryside (Hickman, 2018). Individual scholarship by physicians played essential roles in western botany, zoology and medicine, from Carl Linnaeus and Charles Darwin to names medical students might recognize, e.g., Herman Boerhaave, Johann Schönlein and their eponymous maladies. Many physicians were avid collectors of plants or otherwise incorporated the natural world into their practices. David Hosack, while serving as physician to Alexander Hamilton and

[1] As Ducarme and Couvet (2020) observe, "nature" is a *panchreston*, a term that can carry so many meanings it begins to lack precision. In this discussion, "nature" or "the natural world" refer to the collection of more-than-human elements (plants, animals, waterbodies, etc.) that exist apart from the built environment, as well as natural elements that are brought into or near built spaces (potted plants, gardens, water features, etc.).

others, engaged in a noble, if ill-fated, struggle to preserve the Elgin Botanic Garden, a now-demolished teaching and research site in New York City (Johnson, 2019).

Today, it seems harder to see a strong link between western medicine and nature. In the authors' collective experience, many healthcare workers report that a wide gap exists between the natural world and their lived experience within healthcare. Practicing medical professionals work long hours, often in windowless rooms, and workplace design tends to emphasize sterility and efficiency over beauty and natural elements (Dijikstra, 2008). Many workers with whom the authors have spoken express an intuitive sense that being outside is health promoting, yet nature prescription programs are far from the norm, as are opportunities for academic inquiry among medical students and physicians regarding environmental psychology. And although the US healthcare industry creates 8.5% of national carbon emissions, few physicians speak about climate change and medicine's role in the global carbon footprint (Dzau et al, 2021; Vogel, 2019).

The authors believe that research within the fields of environmental psychology and ecopsychology is one approach to healing the contemporary rift between nature and western healthcare. Through this work, public health scholars, physicians, landscape designers, plant scientists, psychologists, neuroscientists, and others have sought to understand the therapeutic effects of the natural world. Although research in this area has primarily focused on patient and population-level wellbeing, we believe that exposure to nature is also essential to the wellbeing of healthcare professionals. Perhaps it could even reduce the burnout crisis.

Burnout, as defined by the World Health Organization (2019), is an occupational phenomenon consisting of emotional exhaustion, workplace negativism, and reduced sense of efficacy at one's job. Yet a study of nurses found that those who reported greater perceived exposure to nature at work, usually through window views, showed lower burnout rates in the dimensions of emotional exhaustion and negativism compared to peers (Mihandoust et al, 2021). Similarly, a large study of workers from multiple professions found an inverse relationship between nature exposure and the burnout dimensions of negativism and perceived inefficacy (Hyvönen et al, 2018). Though not a mental health condition itself,

burnout can increase the risk of developing mental health conditions such as anxiety or depression. Interaction with nature, on the other hand, can improve mood and reduce symptoms of anxiety and depression (Paiva et al, 2018). Time spent in nature may also improve creativity and focus while reducing physiological markers of stress such as blood pressure, heart rate and salivary cortisol–all of which are relevant outcomes to chronically stressed healthcare workers (Pires de Rocha et al, 2013).

Notably, the therapeutic value of nature can be found in a wide variety of locations, from gardens to wilderness, and bringing nature indoors through houseplants, natural light or other natural features can offer similar benefits to outdoor settings. For instance, greater natural light exposure during work is a predictor for greater job satisfaction and reduced work-related stress among nurses (Alimoglu and Donmez, 2005), and some studies suggest that indoor plants can increase worker productivity and satisfaction while reducing stress, heart rate and blood pressure (Bringlismark et al, 2007; Thatcher et al, 2020; Lee et al, 2015; Dravigne et al, 2008). In that vein, a recent scoping review concluded that incorporating indoor plants into healthcare design is an "efficient, low-cost, highly effective, and sustainable strategy for creating healing and therapeutic environments" (Moslehian et al, 2023).

Adding indoor plants and other natural elements to clinics and workrooms is convenient, allowing for passive exposure to nature without compromising workflow and workload. Maintenance of gardens and indoor plants can be outsourced to horticultural professionals (although giving staff the chance to care for plants can offer added health benefits to those individuals) (Ma, 2022). Concerns about the sanitation of indoor plants for immunocompetent individuals have been debunked by multiple studies, but it may be necessary to educate concerned staff about the many benefits and minimal health risks of indoor plants (Moslehian et al, 2023).[2] Already, many health systems are bringing touches of nature to their facilities through indoor and outdoor gardens, outdoor eating areas, living walls, greater natural light and more. Research often focuses on patients when measuring the effects of such interventions, but healthcare

[2] Strengthening the ties between medicine may offer a bonus to society: people with greater exposure to nature are more likely to engage in pro-environmental behaviors (Liu et al, 2022). Perhaps medical professionals will be more likely to advocate for environmental concerns if they experience the therapeutic effects of nature in their daily work.

professionals, who may spend most of their careers in these environments, should not be forgotten. More nature-based design studies should also focus on burnout as defined by Maslach and Jackson's (1981) seminal burnout inventory, a topic that has insufficient research but potentially wide-ranging implications.

Incorporating nature and natural features into healthcare environments is not the single answer to the professional and mental health crises seen among healthcare workers, and relatively low-cost bandages such as indoor plants and gardens should not be applied to healthcare systems while ignoring deeper issues. At the same time, interaction with the natural world is not an indulgence: it is a necessary ingredient of human health and wellbeing. Healthcare workers have a right to experience nature's health promoting traits through the increased presence of plants and other natural elements at work, and greater nature exposure is an important step toward improving workforce wellness. The COVID-19 pandemic led to a surge of interest among Americans in gardens, indoor plants, and spending time outdoors. It is time for healthcare to embrace these trends. By returning to its natural roots, healthcare can help to facilitate its own healing.

CHAPTER 2

The Effect of Indoor Plants on Workplace Wellness in Primary Care Workers: Results of a Mixed-Methods Pilot Study

1. Introduction

The American Medical Association has called burnout in medicine an epidemic, noting that 63% of U.S. physicians exhibit at least one dimension of burnout (American Medical Association, 2023). Although the National Academy of Medicine labeled burnout as a crisis in early 2020, the disruption of the health system from the COVID-19 pandemic nearly doubled physician burnout rates between 2020 and 2021 (Murthy, 2022). A 2022 national survey found that one in five doctors planned to leave their current practices or the field of medicine within the next two years, while 67% of nurses planned to leave their current positions within the next three years (Henry, 2022; Carbajal, 2022).

The World Health Organization (2019) defines burnout as an occupational phenomenon resulting from chronic, poorly managed workplace stress. Burnout in healthcare consists of three dimensions, first defined by Maslach and Jackson in 1981: emotional exhaustion (characterized by difficulty with emotional engagement at work), workplace negativism (cynicism and decreased compassion, especially toward patients), and reduced efficacy (reduced subjective sense of professional accomplishment) (Maslach and Jackson, 1981). Besides leading to job attrition, burnout can compromise quality of patient care, patient satisfaction, and quality of life for employees, also increasing the risk of anxiety, depression, unhealthy substance use, and problems in personal relationships in burned out individuals (Abraham et al, 2019; Han et al, 2019; De Hert, 2020; Panagioti et al, 2018). Predictors of burnout include a heavy workload, working long hours, caring for high complexity patients, and working in a high acuity setting (Abraham et al, 2019; Kumar, 2018). Poor relationships with leadership and a sense of insufficient autonomy in one's job can also put workers at risk for burnout, as can personal factors such as personality traits (e.g., neuroticism), age and gender, with younger people and women being more likely to report burnout (Shanafelt et al, 2015; Brown et al, 2022; Amoafo et al, 2015). On the other hand, good communication with colleagues, sense of cohesiveness in the workplace and sufficient workplace

resources have been found to be protective against burnout (Abraham et al, 2019; Buckley, 2020). Strong social support outside of work, a personal calling to medicine, and the practice of mindfulness can also be protective (Eckleberry-Hunt et al, 2009; Abraham et al, 2019; Olson et al, 2015).

One area of research that has been insufficiently explored is the effect of the built environment on burnout. The Job-Demand Resources Model posits that job resources, which can be physical, social or organizational factors supporting success in a professional role, preserve high job motivation among workers even in the context of jobs with high demands (Bakker and Demerouti, 2007). Low resources, in contrast, tend to lead to low motivation among workers in high or low job strain settings (Bakker and Demerouti, 2007). As Bellini et al (2007) posit, the built environment should be considered a resource, since sufficient comfort or other positive aspects of the environment could boost motivation and protect against job stress. This may, in turn, protect against burnout.

Although the exploration of the built environment and burnout is limited, research has suggested that indoor environments with natural elements, particularly those with indoor plants, can improve a variety of forms of workplace wellness (wellness a "dynamic, ongoing process" resulting in "optimal state of health" for (Richardson et al, 2017).[3] For instance, research subjects have shown improved verbal task performance and mood when potted plants are nearby (Shibata and Suzuki, 2004). A study of nearly 400 Norwegian office workers found that indoor plants near a worker's desk were correlated with reduced number of sick days and increased self-reported productivity (Bringlismark et al, 2007). A study of 450 U.S. office workers found that those who worked in offices with live indoor plants, or those who had window views of greenery, reported significantly more job satisfaction, especially regarding interactions with colleagues, and enhanced quality of life compared to workers without nearby plants or views of greenery (Dravigne et al, 2008). In the context of healthcare, however, research on the effects of indoor plants or window views of greenery has tended to focus on patient outcomes. Most of these studies

[3] "Wellness" may be another *panchreston*. In this research, a definition influenced by the World Health Organization (2023) and Eckleberry-Hunt (2009, p. 227) is used. Wellness not merely the absence of burnout, but rather "the ongoing and dynamic process" of optimizing physical, mental and emotional wellbeing for workers.

have shown positive effects: for instance, the seminal study behind Ulrich's theory of stress reduction (1984) found that views of greenery from hospital rooms reduced length of hospital stay and use of pain medication after cholecystectomy. Other studies followed to reveal a range of health-promoting effects from indoor plants, such as reduced anxiety and use of pain medications in patients recovering from surgery and better outcomes for seniors with hypertension and dementia (Park and Mattson, 2008; Han et al, 2022; Elsadek and Liu, 2021).

Studies of the positive effects of indoor plants or other natural elements are often predicated on one or more of three core theories within environmental psychology. The Stress Reduction Theory (SRT) asserts that unthreatening natural environments reduce psychophysiological arousal compared to the built environment due to a biological preference for natural spaces, ingrained over millennia of human evolution (Ulrich, 1993). This biologically ingrained comfort with natural spaces and non-human organisms was coined *biophilia* by E.O. Wilson (1984). The Attention Restoration Theory (ART), which builds on SRT and biophilia, posits that the relaxing qualities of natural environments restore our physical and mental energy by attracting cognitively easy, involuntary attention ("soft fascination"), thereby allowing more effortful forms of attention to rest (Kaplan, 1995). Although research in restorative environments has focused primarily on outdoor environments, these theories may be relevant to indoor environments, too (Bringlismark et al, 2009). In the context of modern workplaces, the theories suggest that biophilic features, such as indoor plants, should contribute to reduced stress and enhanced attentive capacity, potentially manifesting in reduced burnout or dimensions of burnout.

Some research supports this possibility. For instance, the presence of greenery may reduce organizational cynicism and enhance workplace engagement (Bellini et al, 2015). A 2018 study explored burnout and nature exposure (including access to indoor plants and other natural elements at work) and found that increased exposure to nature during work hours or in personal pursuits led to reduced burnout symptoms in the dimensions of workplace negativism and reduced efficacy (Hyvönen et al, 2018).

However, an observational study of radiology workers in Norway is one of the only studies centered on the effects of indoor plants on healthcare workers (Fjeld, 2000). Although a 2021 study found

that perceived nature exposure at work may mitigate burnout in the dimensions of emotional exhaustion and workplace negativism, nature exposure in this study was most commonly reported as view of nature through windows, and no studies to date have investigated the particular impact of indoor greenery on burnout in healthcare workers.

Research aim

Insufficient research exists that investigates the effects of built environmental conditions, restorative environmental conditions, or biophilic elements on burnout, particularly among healthcare workers. In this mixed methods pilot study of primary care[4] workers, we sought to explore the impact of indoor plants (one element of a biophilic built environment) in medical offices on worker burnout levels. We also aimed to explore the mediating effect that self-reported connectedness to the natural world might have on burnout. We predicted that the presence of indoor potted plants would mitigate burnout levels in participants. We also predicted that high self-reported connectedness to the natural world would enhance this mitigating effect. We chose to investigate the effects of indoor plant treatment on primary care workers given the importance of primary care to most national healthcare systems. In both developed and developing nations, the presence of primary care has been associated with better population health outcomes, reduced hospitalization rates and reduced use of emergency services (Shi, 2012). In the U.S., primary care doctors show high burnout rates compared to many other fields within medicine (Agarwal et al, 2020).

[4] Primary care is "the provision of integrated, accessible health care services by physicians and their health care teams 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. The care is person-centered, team-based, community-aligned, and designed to achieve better health, better care, and lower costs" (American Academy of Family Physicians, 2021, para. 2). In the U.S., primary care is usually represented by family medicine, internal medicine, or pediatric providers and support staff.

2. Methods

2.1 Clinic Selection

Four primary care clinical sites located within 30 miles of Ithaca, New York, were selected to participate in this study. The clinics are all affiliates of Cayuga Health System and are of a similar size, ranging from three to nine administrative workers (including patient service representatives, medical records or billing personnel), three to nine clinical support staff (including nurses, nurse care managers, or medical assistants), and four to thirteen providers (including physicians, nurse practitioners, physician assistants, or resident physicians) (Table 1). The sites represent two family medicine clinics and two internal medicine clinics. One internal medicine clinic also serves immunology and rheumatology patients and is affiliated with a rural internal medicine residency program.

Table 1: Clinic Characteristics

Clinic ID	Study group	Specialty	Administrative Staff	Clinical Support Staff	Providers
T1	Treatment*	Family Medicine	3	6	4
T2	Treatment	Internal Medicine**	5	3	13
C1	Control	Internal Medicine	9	9	7
C2	Control	Family Medicine	7	4	5

*Plants were present in patient exam rooms
**Residents rotate through this clinic, contributing to a higher provider number

The sites were randomized into treatment and control groups using a random number generator. In mid-April 2022, all clinics received a survey which was distributed to employees by the office managers or stand-in office managers. Two weeks after survey administration, the treatment clinics received a variety of species of non-flowering, unscented, low-light tolerant houseplants ranging in pot size from 4 to 10 inches (10 to 26 cm) (Table 2). The plants were placed by the research team throughout the clinic in areas approved of by office leaders, with the goal of minimizing work interruptions while adhering as closely as possible to the plant density of "one large plant and one small plant per 6 m^2" recommended by the Rural Development Administration of South Korea (Figure 1) (Han, 2022). Pot size

and particular variety of plant were selected by the greenhouses that donated to this study (see *Appendix*). Locations where plants were placed included: break rooms, provider work rooms, nursing stations, front desk, waiting rooms, and, in one clinic, in a hallway near a water cooler. In one treatment site (Clinic ID: T1), plants were placed in exam rooms, while the other site (Clinic ID: T2) did not have plants in exam rooms due to administrative preference.

Scientific name	**Common name**
Aeonium sp.	Tree houseleeks
Aloe barbadensis	Aloe
Dracaena fragrans	Corn plant
Dracaena trifasciata	Snake plant
Echeveria subsessilis	Echevaria 'Morning Beauty'
Epipremnum aureum	Golden pothos
Epipremnum aureum 'Neon'	Neon pothos
Ficus lyrata	Fiddle-leaf fig
Guzmania lingulata	Guzmania bromeliad
Monstera deliciosa	Monstera
Maranta leuconeura	Prayer plant
Philodendron hederaceum 'Brasil'	Philodendron 'Brasil'
Plectranthus australis	Swedish ivy
Schleffera arboricola	Schleffera
Spathiphyllum wallisii	Peace lily
Tradescantia zebrina	Wandering dude

Table 2: Indoor plant species used in offices

Figure 1: Before/after images of a nursing station (top) and entrance to a break room (bottom)

The plants remained in the treatment offices for two months, during which two follow-up surveys, one month apart, were administered to both treatment and control sites. Office managers or stand-in managers were informed of the nature of the study but were requested to not share this with staff until the end of two-month treatment period and subsequent qualitative interviews. At the end of the treatment period, treatment clinics were offered the option to keep the plants, return them, or allow workers to take them home. Qualitative interviews were performed with workers in the 6 months following the treatment period (see *Qualitative Methods*). Participants were formally informed of the nature of the study after the interviews concluded.

2.2 Survey and Statistical Methods

We developed a set of online surveys using Qualtrics, consisting of demographic questions (age range, gender, race, ethnicity, professional role, and years in current position); the Maslach Burnout Inventory™ (MBI); and the abbreviated Nature Relatedness Scale (NR6) (see *Appendix*) (Nisbet and Zelenski, 2013). The MBI is a validated survey consisting of 22 items on a seven-point scale (0 = 'never' to 6 = 'every day') to measure three dimensions of burnout. We used the official version of the MBI designed by Mind Garden, Inc. for healthcare professionals (Mind Garden, Inc., 2023). The NR6 is a validated survey consisting of six items on a five-point scale (0 = 'disagree' to 4 = 'agree') to measure sense of connection to the natural world.

The first survey was sent to office managers or stand-in office managers at the four clinical sites, who then distributed the survey to clinical and administrative staff one week prior to the placement of plants in the treatment offices. The managers at the treatment sites were requested to not participate in the surveys, since they had helped with placement of plants in the offices. Two follow-up surveys, consisting of abbreviated demographic questions (which included professional role but did not include age range, race, or gender), the MBI, and the NR6, were administered at monthly intervals thereafter. Workers were encouraged by managers to complete all three surveys; however, they were permitted to participate in Surveys 2 and 3 even if they had not completed the first survey. Participants gave written consent at the beginning of each survey in accordance with Cornell University IRB guidelines. Participation in the study was voluntary, and confidentiality was emphasized in written communication. At the end of the study, participants who completed all three surveys were given a $20 gift certificate to a local coffee shop, and participants who completed two surveys were given a $10 gift certificate. The study was approved by the Institutional Review Boards of Cornell University and Cayuga Medical Center.

After collection, survey data was cleaned to exclude surveys that were less than 70% complete. This comprised thirty-one surveys. Two other surveys were not completed sufficiently to know the job title of the respondents and thus also excluded. One further survey was excluded because it had been completed by a stand-in practice manager. The survey data was analyzed with JMP Pro® 16 software

using linear mixed effects models with MBI burnout score as the response variable. To determine if changes in burnout score over time differed between treatment groups, we fit a linear mixed effects model with fixed effects of treatment, survey number, and their interaction, and random effects of clinic and subject ID nested within clinic. To investigate changes at specific clinics, we fit a second linear mixed model with fixed effects of clinic (four levels), survey number and their interactions, with a random effect of participant ID. Next, to investigate changes in burnout score by clinical role, we fit a linear mixed model using fixed effects of clinical role, treatment, survey number and all interactions, and random effects of clinic and participant ID nested within clinic. There were insufficient numbers of completed surveys and distribution of NR6 scores to allow incorporation of NR6 as a moderator in these models. However, to assess the effect of nature relatedness, we created a linear mixed effects model using total MBI burnout score as the response variable, with NR6 score, treatment, and survey number as fixed effects, and clinic site and participant ID as random effects.

2.3 Interview Methods and Analysis

Brief interviews were conducted to better understand the influence of plants and other natural elements on workplace burnout. All participants except for the upper-level administrator were selected by asking office managers or stand-in managers to identify participants who represented a mix of clinical and administrative roles. Participants were not required to have completed the surveys but were required to have worked at the clinics during the survey period. Thirteen workers participated, including an office manager at one treatment site and at one control site, a mix of clinical and administrative staff at all four study sites, and an upper-level administrator who did not work at the study clinics. Before beginning interviews, participants gave verbal consent in accordance with Cornell University IRB requirements. They received a $10 gift card to a local coffee shop and a small potted plant as payment.

Our team developed two semi-structured interview guides, for both staff and management, to explore personal experiences and conceptions of burnout, relationships to the natural world, and ideas for wellness-focused healthcare design (See *Appendix*). Staff and management in the treatment group were

also asked to describe their attitudes toward the addition of plants in the workspace during the treatment period. To gather both phenomenological and feasibility data, management was asked to comment on the feasibility of having plants in their offices beyond the study period. Interviews were recorded using Zoom and a digital voice recorder. Ten interviews were conducted at the clinics in quiet spaces to promote privacy. Due to scheduling conflicts, three participants chose to interview remotely using a phone or Zoom audio. Interviews took place between September 2022 and March 2023.

One member of the research team (CG) transcribed the interviews. CG performed thematic analysis of the interviews using immersion crystallization (IC) technique, an inductive, iterative method of identification of themes and subsequent interpretations, first characterized by Miller and Crabtree and later developed by Borkan (Crabtree and Miller, 1992; Borkan, 2022). Adhering to IC methods, audio files and transcripts were evaluated repeatedly to identify themes and patterns. An initial codebook was developed using NVivo software after the first round of reading transcripts; this was refined through subsequent rounds of data immersion. Due to accidental damage of a data storage device, three interview recordings were lost prior to being transcribed; however, detailed notes had been taken during the interviews, which were incorporated into thematic analysis.

3. Results

Survey Results

Participant characteristics and response rates

A total of 50 staff members participated in the three surveys. Surveys 1, 2 and 3 had 37, 31 and 27 respondents, respectively. The response rate among staff groupings at each clinic ranged from 0 to 100 percent depending on the survey, with an average response rate of 41% among providers, 41% among clinical support, and 47% among administrative staff across the four clinics and three surveys (Table 3).

	Survey 1	Survey 2	Survey 3
Clinical Site Staff Group	**Respondents (% at clinic)**	**Respondents (% at clinic)**	**Respondents (% at clinic)**
T1			
Provider	1 (25)	2 (50)	2 (50)
Clinical Support	5 (83)	5 (83)	4 (67)
Administration	3 (100)	1 (33)	2 (67)
T2			
Provider	6 (46)	4 (31)	7 (54)
Clinical Support	1 (33)	3 (100)	1 (33)
Administration	2 (40)	2 (40)	0 (0)
C1			
Provider	3 (43)	1 (14)	0 (0)
Clinical Support	3 (33)	3 (33)	1 (11)
Administration	7 (78)	5 (56)	5 (56)
C2			
Provider	3 (100)	1 (33)	2 (67)
Clinical Support	0 (0)	1 (25)	1 (25)
Administration	3 (43)	3 (43)	2 (29)
Total Survey Respondents	37	31	27

Table 3: Response rate by professional role, clinic and survey number

Among respondents to Survey 1 (38 respondents), in which most demographic questions were asked, the majority were female (84%) and of European descent (62%). The most common age range was between ages 31 and 40 (27%). Administrative workers were the most represented clinical group (41%), while providers comprised 35% and clinical support 24% of Survey 1 respondents (Table 4).

Demographic results of Survey 1						
		T1	**T2**	**C1**	**C2**	**Total**
Gender Identity	Female	7	7	12	5	31
	Male	1	2	1	1	5
	Not reported	1	0	0	0	1
Racial Identity	African American	0	0	0	1	1
	Asian American	0	3	0	0	3
	European American	8	3	9	3	23
	Mixed race or other	0	2	1	0	3
	Native American or Pacific Islander	0	0	0	1	1
	Prefer to not say	1	1	3	1	6
Age Range	18-30	3	1	2	2	8
	31-40	3	6	1	0	10
	41-50	2	2	3	1	8
	51-60	0	0	5	0	5
	60+	0	0	2	3	5
	Not reported	1	0	0	0	1

Professional Role	Provider	1	6	3	3	13
	Clinical Support	5	1	3	0	9
	Administration	3	2	7	3	15

Table 4: Demographic characteristics of respondents for Survey 1

Burnout trends by treatment group

Table 5 shows the sample size, mean and standard deviation for burnout scores over the three surveys as a function of treatment group. The mean difference in MBI score for between control and treatment groups changed from 7.0 to 14.7 between Surveys 1 and 3, with the control score increasing 9.0 points from baseline and the treatment group increasing 1.3 points from baseline. A linear mixed effects model found no statistical significance. Table 6 shows the results of this model. Participant ID accounted for 66% and clinic site for 27% of random variance. Figure 2 shows trends in total burnout score by treatment group over time. Tables 7-9 show the sample size, mean and standard deviation for each dimension of burnout score (emotional exhaustion, workplace negativism, and lack of efficacy). Each separate dimension of burnout showed parallel trends to total burnout scores, with control scores increasing more than treatment scores over time.

MBI Total by Treatment Group									
	Survey 1			**Survey 2**			**Survey 3**		
Treatment Group	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	18	45.8	21.7	13	46.2	24.1	11	54.8	24.6
Treatment	19	38.8	22.4	18	36.6	22.5	16	40.1	22.8

Table 5: MBI total scores by treatment group

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MBI Total by Treatment Group					
Source	**Nparm**	**DF**	**DFDen**	**F Ratio**	**Prob > F**
Survey #	2	2	45.07	1.5066	0.2326
Survey #*Treatment	2	2	45.07	2.0773	0.1371
Treatment	1	1	1.977	0.0923	0.7903

Table 6: Results of fixed effect tests for MBI total by treatment group

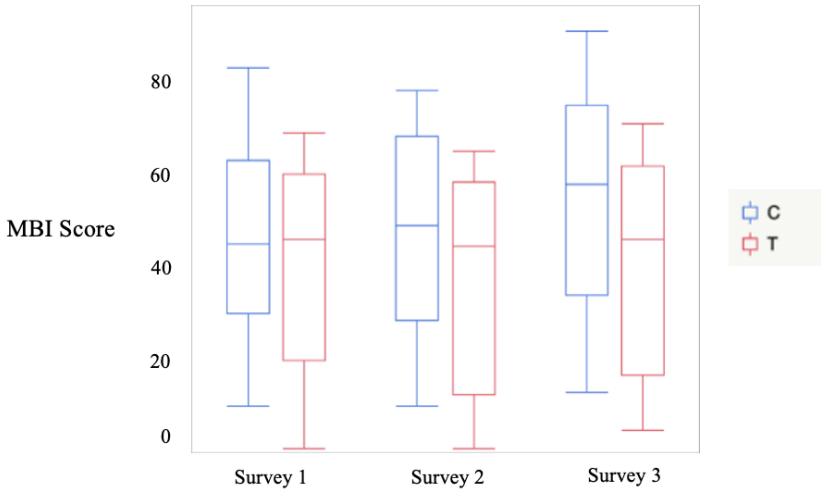

Figure 2: MBI total score over three surveys in treatment and control groups

MBI Emotional Exhaustion by Treatment Group									
	Survey 1			**Survey 2**			**Survey 3**		
Treatment Group	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	18	6.9	6.4	12	8.4	7.9	10	10.2	8.3
Treatment	19	5.5	5.0	14	3.9	3.4	15	5.4	5.7

Table 7: MBI emotional exhaustion scores by treatment group

MBI Workplace Negativism by Treatment Group									
	Survey 1			Survey 2			Survey 3		
Treatment Group	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	18	28.6	12.2	13	28.5	13.6	10	35.5	12.3
Treatment	19	24.6	15.7	17	23.4	16.2	16	27.8	17.5

Table 8: MBI workplace negativism scores by treatment group

MBI Lack of Efficacy by Treatment Group									
	Survey 1			Survey 2			Survey 3		
Treatment Group	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	17	10.9	7.0	13	10.0	5.8	9	13.5	7.9
Treatment	19	8.7	6.4	16	8.6	7.4	15	8.8	4.8

Table 9: MBI lack of efficacy scores by treatment group

Burnout trends by clinic site

Table 10 shows the sample size, mean and standard deviation for burnout scores over the three surveys as a function of treatment group and clinic site. All clinics except for T2 increased in burnout scores over time (T2 decreased in MBI scores by 3.1 points). MBI scores at clinic C2 increased the most from Survey 1 to Survey 3 (12.6 points). These findings were not statistically significant. Table 11 reports results of fixed effects tests. In REML analysis, participant ID accounted for 90% of variance while clinic site accounted for 10% of variance. Figure 3 shows trends in total burnout scores by clinic site over time. Tables 12-14 show the sample size, mean and standard deviation for each dimension of burnout score (emotional exhaustion, workplace negativism, and lack of efficacy) as a function of treatment group and clinic site. Each separate dimension of burnout showed parallel trends to total burnout scores, with control site scores increasing more than treatment site scores over time.

MBI Total by Clinic Site										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**Treatment Site**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	C1	13	48.6	29.6	9	48.3	21.5	6	57.8	23.4
	C2	5	38.6	27.4	4	41.5	32.3	5	51.2	28.2
Treatment	T1	8	48.5	17.0	8	50.4	13.6	8	51.8	18.7
	T2	11	31.7	23.8	10	25.5	22.5	8	28.6	21.4

Table 10: MBI total scores by treatment group and clinic site

MBI Total by Clinic Site					
Source	**Nparm**	**DF**	**DFDen**	**F Ratio**	**Prob > F**
Survey #	2	2	43.79	1.1337	0.3311
Site	3	2	.	.	.
Treatment	1	0	.	.	.
Survey #*Site	6	6	42.71	1.2423	0.3043

Table 11: Fixed effect tests for MBI total by clinic site

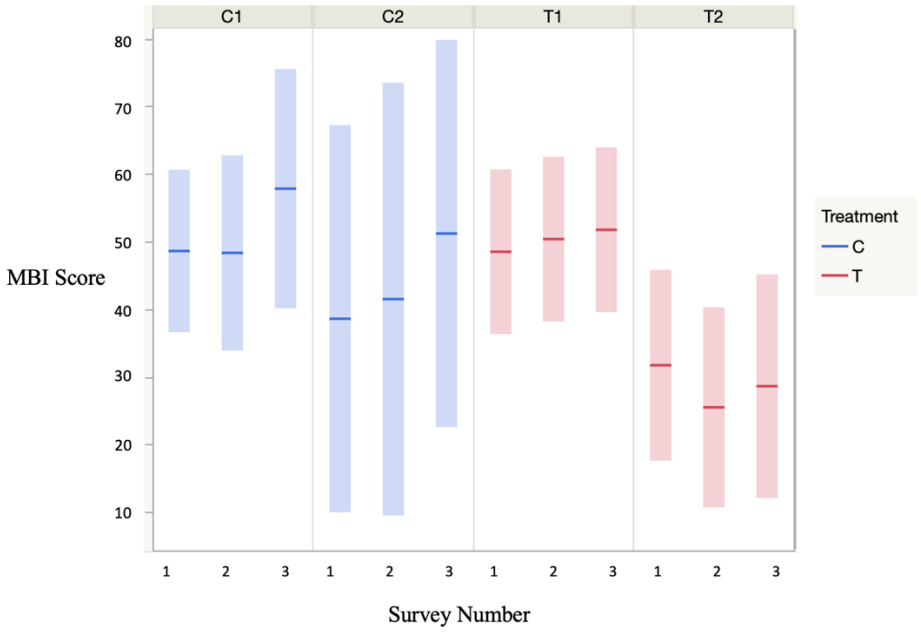

Figure 3: MBI total score over three surveys in treatment and control sites

MBI Emotional Exhaustion by Clinic Site										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**Treatment Site**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	C1	13	6.8	6.4	8	9.6	8.2	6	9.8	8.3
	C2	5	7.0	7.2	4	6.0	7.9	4	10.8	9.5
Treatment	T1	8	7.0	5.6	7	5.9	3.2	8	8.3	6.6
	T2	11	4.4	4.4	7	2.0	2.3	7	2.1	1.3

Table 12: MBI emotional exhaustion scores by treatment group and clinic site

MBI Workplace Negativism by Clinic Site										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**Treatment Site**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	C1	13	30.6	10.6	9	28.9	11	5	36.0	10.1
	C2	5	23.2	15.6	4	27.5	20.4	5	35.0	15.4
Treatment	T1	8	32.5	12.9	8	29.6	13.5	8	33.8	12.6
	T2	11	18.9	15.6	9	17.8	17.1	8	17.8	18.7

Table 13: MBI workplace negativism scores by treatment group and clinic site

MBI Lack of Efficacy by Clinic Site										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**Treatment Site**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	C1	12	12.0	7.4	9	10.9	6.1	6	15.5	8.3
	C2	5	8.4	5.8	4	8.0	5.3	3	9.7	6.7
Treatment	T1	8	9.0	4.9	8	14.0	5.3	8	9.8	4.8
	T2	11	8.5	7.5	8	3.3	5.0	7	7.7	5.0

Table 14: MBI lack of efficacy scores by treatment group and clinic site

Burnout and professional role

Table 15 shows the sample size, mean and standard deviation over the three surveys as a function of treatment group and professional role. In the control group, provider MBI scores increased by 22.3 points from Survey 1 to Survey 3, while treatment providers showed the only decrease in burnout scores (7.3 points). Clinical support in the control group showed the greatest increase in burnout (27.2 points) during this period, though clinical support in the treatment group had a smaller increase in burnout (8.1 points). A linear mixed effect model, however, found these trends to be insignificant. Table 15 reports the results of this analysis. Participant ID accounted for 63% and clinic site for 30% of variance. Figure 4 shows these non-significant trends in total burnout scores. Tables 16-18 show the sample size, mean and standard deviation for each dimension of burnout score (emotional exhaustion, workplace negativism, and lack of efficacy) as a function of treatment group and professional role. Each separate dimension of burnout showed similar trends to total burnout scores.

MBI Total by Professional Role										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**Professional Role**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Administration	10	47.5	27.1	8	42.4	22.3	7	48.4	25.6
	Clinical Support	3	31.3	9.7	3	42.3	33.5	2	58.5	23.3
	Provider	5	51.2	9.6	2	67.5	13.4	2	73.5	23.3
Treatment	Administration	4	19.3	17.0	3	31.3	21.2	2	29.0	24.4
	Clinical Support	6	49.5	14.7	8	41.4	21.5	5	57.6	8.6
	Provider	8	40.3	24.6	7	33.3	26.1	9	33.0	24.2

Table 14: MBI total scores by treatment group and professional role

MBI Total by Professional Role					
Source	**Nparm**	**DF**	**DFDen**	**F Ratio**	**Prob > F**
Survey #	2	2	43.24	1.0511	0.3583
Professional Role - Clean	2	2	63.19	1.7542	0.1814
Treatment	1	1	2.026	0.3377	0.6193
Survey #*Site	6	6	42.28	1.3045	0.2762

Table 15: Fixed effect tests for MBI total by professional role

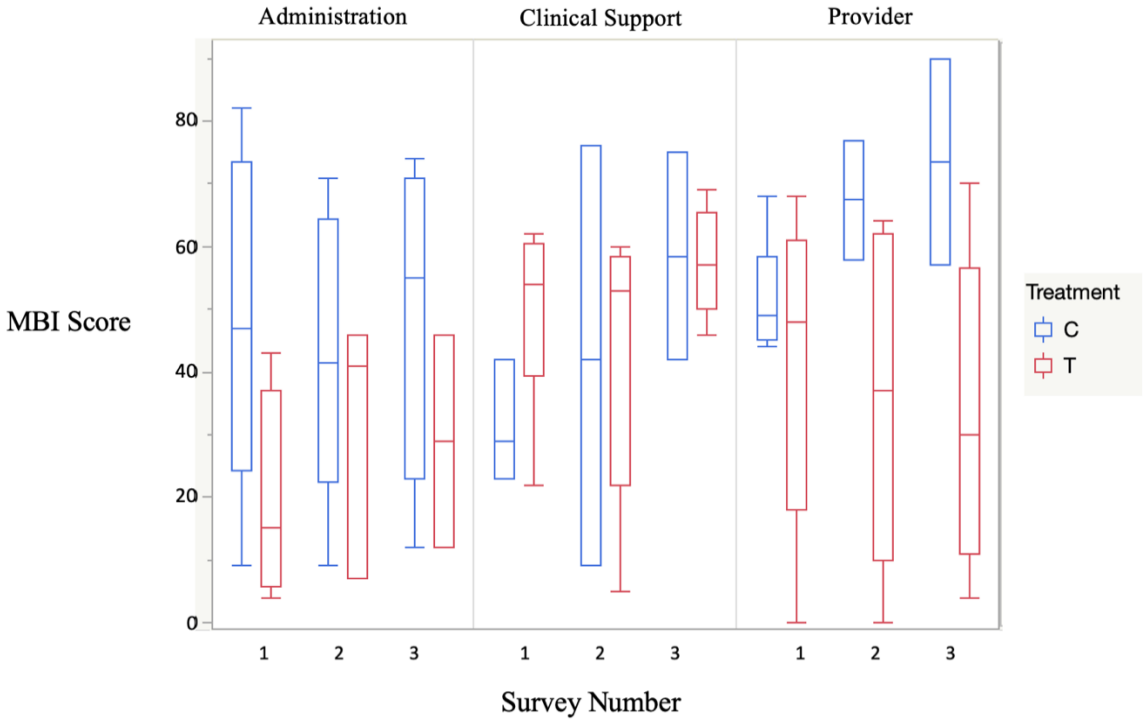

Figure 4: MBI total score by professional role

MBI Emotional Exhaustion by Professional Role										
		Survey 1			**Survey 2**			**Survey 3**		
Treatment Group	**Professional Role**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Administration	10	7.7	6.9	7	7.3	7.1	7	6.0	5.5
	Clinical Support	3	4.7	6.4	3	9.0	12.2	1	23.0	
	Provider	5	6.6	6.5	2	11.5	7.8	2	18.5	3.5

Treatment	Administration	4	1.8	3.5	1	8.0		2	4.5	6.4
	Clinical Support	6	4.8	4.9	7	3.7	2.5	5	5.8	2.7
	Provider	9	7.6	4.9	6	3.5	4.3	8	5.3	7.4

Table 16: MBI emotional exhaustion scores by treatment group and professional role

MBI Workplace Negativism by Professional Role										
		Survey 1			**Survey 2**			**Survey 3**		
Treatment Group	**Professional Role**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Administration	10	27.7	14.8	8	26.3	11.8	6	31.2	13.5
	Clinical Support	3	21	8.2	3	25	19	2	39.5	6.3
	Provider	5	34.8	3.1	2	42.5	6.4	2	44.5	10.6
Treatment	Administration	4	11.5	14.5	2	8	2.8	2	18.0	12.7
	Clinical Support	6	35.2	8.9	8	27.6	15.3	5	41.6	3.6
	Provider	9	23.4	16.1	7	22.9	18	9	18.7	17.8

Table 17: MBI workplace negativism scores by treatment group and professional role

MBI Lack of Efficacy and Professional Role										
		Survey 1			**Survey 2**			**Survey 3**		
Treatment Group	**Professional Role**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Administration	9	13.3	8.2	8	9.8	6.5	6	15.5	8.3
	Clinical Support	3	5.7	4.9	3	8.3	6.0	1	8	
	Provider	5	9.8	3.4	2	13.5	0.7	2	10.5	9.2
Treatment	Administration	4	6.0	5.5	2	11.5	16.3	2	6.5	4.9
	Clinical Support	6	9.5	5.5	7	10.9	7.1	5	10.2	6.1
	Provider	9	9.3	7.5	7	5.6	5.0	8	8.5	4.4

Table 18: MBI lack of efficacy scores by treatment group and professional role

Nature Relatedness and MBI Scores

Figure 5 shows the distribution of NR6 values for all three surveys. As evidenced by the figure, NR6 scores were skewed to higher values: across the three surveys, the mean for NR6 was 20 with a standard deviation of 4.2, and the range was 3-24 (maximum score = 24). To evaluate the effect of NR6 on MBI, participant scores were grouped by above or below-mean NR6. Table 19 shows the sample size, mean and standard deviation over the three surveys as a function of treatment group and NR6 group. Below-mean NR6 control participants had the only decrease in burnout scores over the three surveys (-6 points from Survey 1 to Survey 3), while below-mean NR6 controls had the largest increase in burnout (14.8 points). A linear mixed effect model found no statistical significance. Table 20 results of fixed effects tests. In REML analyses, participant ID contributed to 70% of variance, while clinical site contributed to 25% of variance. Figure 5 illustrates these non-significant trends for NR6 and MBI total. Tables 21-23 show the sample size, mean and standard deviation for each dimension of burnout score (emotional exhaustion, workplace negativism, and lack of efficacy) as a function of treatment group and NR6 group. Each separate dimension of burnout showed similar trends to total burnout scores.

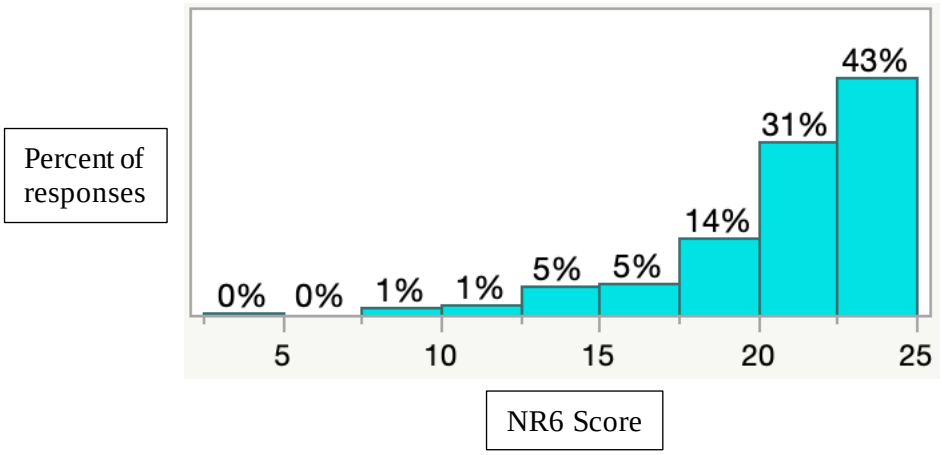

Figure 5: NR6 distribution across all surveys

MBI total by NR6										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**NR6 grouping**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Above mean	13	44.3	21.1	9	42.2	24.1	6	46.7	25.6
	Below mean	5	49.8	25.2	4	55.3	24.8	5	64.6	21.6
Treatment	Above mean	12	39.4	24.8	12	36.8	25.0	10	45.3	24.9
	Below mean	7	37.7	19.3	5	42.0	13.2	6	31.7	17.5

Table 19: MBI total scores by treatment group and NR6 group

MBI total by NR6					
Source	**Nparm**	**DF**	**DFDen**	**F Ratio**	**Prob > F**
Treatment	1	1	1.972	0.0912	0.7916
NR6 Grouping	1	1	52.49	0.5342	0.4681
Survey #	2	2	41.76	1.114	0.3378
Survey #*Site	6	6	39.61	1.304	0.2779

Table 20: Fixed effect tests for MBI total by NR6 group

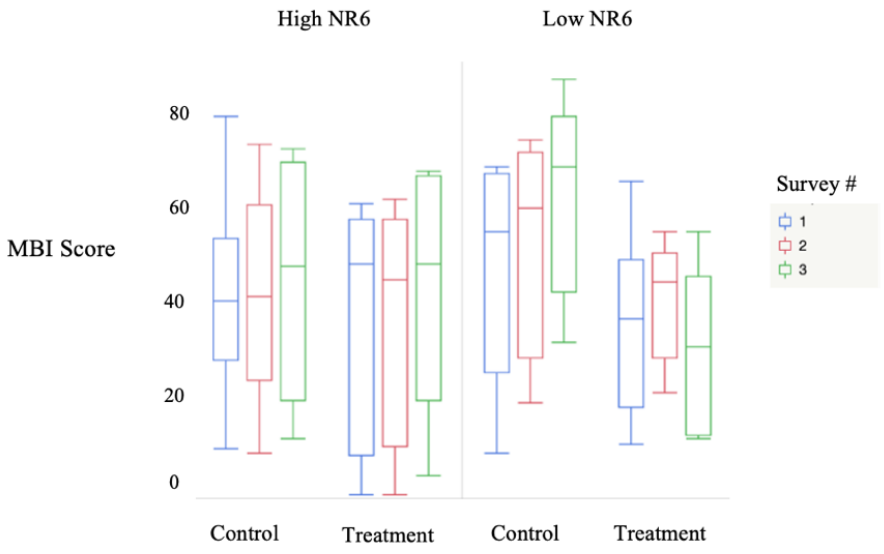

Figure 6: MBI total score over time comparing by above mean and below mean NR6

MBI Emotional Exhaustion by NR6										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**NR6 grouping**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Above mean	13	6.3	6.1	8	7.3	7.5	5	10.2	10.1
	Below mean	5	8.4	7.8	4	10.8	9.4	5	10.2	7.3
Treatment	Above mean	12	5.4	5.4	11	2.8	2.6	10	5.8	6.2
	Below mean	7	5.6	4.6	3	8.0	2.6	5	4.6	5.0

Table 21: MBI emotional exhaustion scores by treatment group and NR6 group

MBI Workplace Negativism by NR6										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**NR6 grouping**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Above mean	13	27.9	11.5	9	26.6	13.6	5	31.6	12.9
	Below mean	5	30.2	15.2	4	32.8	14.4	5	39.4	11.8
Treatment	Above mean	12	27.3	16.8	12	23.7	18.2	10	30.3	19.0
	Below mean	7	20.1	13.8	4	26.8	8.4	6	18.2	12.6

Table 22: MBI workplace negativism scores by treatment group and NR6 group

MBI Lack of Efficacy by NR6										
		Survey 1			Survey 2			Survey 3		
Treatment Group	**NR6 grouping**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Control	Above mean	12	10.8	7.8	9	9.2	6.2	4	11.8	10.3
	Below mean	5	11.2	5.1	4	11.8	3.2	5	15.0	6.3
Treatment	Above mean	12	6.8	5.6	11	9.7	8.2	10	9.2	5.0
	Below mean	7	12.0	6.6	4	7.8	4.6	5	8.0	5.0

Table 23: MBI scores lack of efficacy scores by treatment group and NR6 group

Interview Results

Thirteen participants, comprising seven clinicians, five administrators, and one upper-level manager (the latter not affiliated with a clinic), were interviewed. Eleven of the participants were female and two were male. Participant characteristics are shown in Table 24.

Professional role	Treatment Group	Number
Clinician	Treatment	4
Administration	Treatment	2
Clinician	Control	3
Administration	Control	3
Upper-level management	Not Applicable	1
Total		**13**

Table 24: Interview participant characteristics

Definitions of and experiences with burnout

All participants reported having felt burnt out at some point in their career, and about half of participants (6) reported currently feeling burnt out. Participants identified multiple features of burnout, most of which are categorized under Maslach and Jackson's three categories of burnout dimensions. Eight participants used emotional exhaustion in their definition of burnout, which sometimes included physical exhaustion as well. Said one clinician, "Just fatigue, you know it's like a not a physical--I guess it could translate into a physical--but it's more of an emotional psychological fatigue that is hard to pinpoint the origin. But it seems to just pervade your whole being, and [is] worsened by the workplace." Four participants mentioned depersonalization as a feature of burnout that they or others had experienced. This included disengagement with patients (mentioned by two clinicians) and frustration with colleagues and leadership (mentioned by three participants). One clinician admitted, "I don't care anymore. And that's sca[ry]—I mean, that's terrible. I mean I probably don't treat, I probably don't pay as much attention as I have been. It's like I just let things go. And I mean . . . they aren't emergencies, but I also don't, like, I just let things go." Reduced professional efficacy was another common thread, mentioned by seven participants when describing burnout, often in the form of loss of agency due to an untenable situation. Said one clinician, "Burnout is what happens when a worker is put in a situation that is, for whatever reason, unsustainable, for an extended period of time." An administrative worker described the causes of burnout in their job as

a sense of struggle without reward: "You're getting yelled at, you're having a bunch of that you're talking to every day, you're doing all this and it just feels like it amounts to nothing." Participants also cited loss of enjoyment of a job they previously enjoyed, and two spoke of hopelessness or the belief that their situation, or the situation of healthcare at large, would never improve.

Effects of Nature and Indoor Plants on Wellness and Burnout

Most participants did not specifically suggest that increased exposure to nature or indoor plants could change rates of burnout at their work or in healthcare at large. However, many participants attributed both nature and indoor plants with benefits indirectly related to burnout, such as indicators of wellness and burnout modifiers. Workplace wellness indicators associated with indoor plants and/or exposure to other forms of nature included enhanced mood, reduced anxiety and depression, enhanced physical wellbeing, and cognitive restoration. Treatment with indoor plants and/or exposure to other forms of nature were associated with the burnout modifiers of perception of leadership, mindfulness, and workplace cohesiveness. Participants also reflected on the potential feasibility of maintaining indoor plants in their offices. Their observations are described below.

Wellness indicator: enhanced mood

Most participants in the treatment group suggested that the addition of plants had enhanced the mood of workers. Said one clinician, "The immediate impact was, you could see it, everybody, it was great . . . they [indoor plants] make you feel good." Most workers used terms such as "pleasant" and "enjoyment" to refer to the plants. However, one treatment participant said that the plants had enhanced their mood but were not beneficial to "wellness" (a term that was not formally defined in the interview). Two treatment participants said that patients appreciated the plants and had frequently mentioned this to staff. A strong trend among interview participants was the linking of indoor plants with a sense of home, which was considered a positive addition to the workspace. "Hominess" was linked with warmth, comfort and positive mood. Five participants in the treatment group referenced the quickness with which plants were

taken home by staff after the survey period had finished. A control participant, when describing ideal changes to their office space, said, "I feel like colorful plants would brighten it up in here or even just give it a more homey feel, because most people have plants at home." Participants in both treatment and control groups suggested that being outdoors in natural spaces could enhance their mood, and many reported regularly seeking time outdoors. Said one administrative worker, "Every single day in the morning, me and my dog take a walk through the woods . . . If I don't get that walk because it's raining or something, I don't feel as good during the day . . . being outside and in the woods is one of my absolute favorite things in the entire world."

Wellness indicator: reduced anxiety and depression

"Calming" was commonly used to describe the addition of indoor plants among treatment participants. Another participant, an avid indoor gardener who had coincidentally brought houseplants to his control clinic after the treatment period ended, said, "It's my way of either taking a Xanax or I go water my plants. So I learned that Xanax helps to keep you calm, but after a while, it's like you gotta do this on your own. You gotta figure out some way to do it on your own. And my way of doing it is my plants." When imagining their ideal workplace environment, a clinician in the treatment group described, a "garden [with] like areas to sit . . . I'd probably put like a couple of like picnic style tables out there, so that if you want it to when it's nice, you get to lunch . . . .and a greenhouse thing, where it was roofed. So even when it in the middle of winter, you could go out there and enjoy it, and that would help alleviate like seasonal depression symptoms and stuff like that."

Wellness indicator: enhanced physical wellbeing

Participants associated indoor plants or nature with positive improvements in wellbeing, although for different reasons. Two control participants and one treatment participant believed that some of the therapeutic benefit of indoor plants was related to enhanced air quality. Even so, the treatment participant did not suggest that they had observed enhanced air quality at their clinic due to the treatment. Another

control participant, who had switched jobs after the survey period ended and currently worked in a clinic (not affiliated with this study) that featured many indoor plants, said, "I do think . . . that having plants in a room, especially a medical room, makes a world of difference in terms of people's general energy level." Many participants spoke of being outside in nature as essential parts of their physical wellness: "I think being outside and moving outside is like as important as medicine. Or food or water . . . It's something I have to do every day," said a clinician in the control group." Participants in both treatment and control groups spoke of the mental and physical therapeutic effects of both nature and indoor plants as though it was obvious, e.g., "they all realize that plants help."

Wellness indicator: cognitive restoration

Many participants noted that indoor plants and/or nature promoted wellbeing for them by shifting their perspectives about work stressors. Some described seeing or interacting with plants as opportunities to "take your mind" off bothersome issues at work. One treatment participant described indoor plants as a beneficial "distraction" from the typical healthcare environment, particularly for patients; however, this participant also believed that plants were less helpful for healthcare workers who are "so busy that we can't even take the time to notice." The aforementioned indoor gardener in the control group felt that indoor plants were a form of escape: "Something to get you to escape for a few minutes. . . [my workplace] is sterile in the sense of, there's nothing to look at because you look at it every day, day in, day out. But when you look at a plant, there's always going to be something different about that plant."

Many participants spoke in detail about the restorative effects of outdoor nature. Time in nature was seen as a reminder of one's "place in the world," leading people to view work problems as less important. One clinician reflected, "Being out in nature, doing something outside, kind of reminds me of the bigger picture of the world, you know. And it's just comforting to know that, like, things are moving and growing and living outside of, like, the day-to-day of work when it's really hard." Another said, "Having kind of activities to do outside in nature is a good way to take a brain break from work, and to

just do something that's completely not related to our work. I think that's really important for kind of regenerating your energy every day."

Burnout modifier: perception of leadership

Among some treatment participants, indoor plants were associated a sense of being recognized by their organization. An administrator in the treatment group said that indoor plants from the study had been helpful for morale because their clinic believed itself to be "the redheaded stepchild" of the larger organization, and many workers felt that their concerns had gone unheard or unseen by leadership. The addition of plants made participants feel like the organization had said, "We know you exist and we appreciate you." In contrast, a clinician in the other treatment office initially felt concern when they saw the indoor plants: "So we came here one day and there were plants everywhere, and it seemed like the best thing ever. It was very, very good. And I think it provoked a little bit of anxiety, you know, it was like, 'Well, who's going to take care of them?' . . . In those days, you know [the organization] had been talking about, you know, physician burnout, they were trying to do something, and then we're like, okay, fine, so they just throw a lot of these plants at us and we're supposed to take care of them." However, when management reassured this participant that someone would take care of the plants, the participant's perspective changed: "I mean that, once we found that out, it was like, that's great." In contrast, some participants expressed desire for more biophilic elements, such as open windows (in the summer) and outdoor benches for lunch breaks, but also reported skepticism that their institution's leadership would be willing to implement such wellness initiatives. Distinct from discussions of indoor plants or other natural elements, most people felt that their concerns about burnout were not being sufficiently acknowledged by their organization. Nine people felt that leadership in their clinic or larger organization had failed to address burnout or addressed it poorly. A clinician in the control group suggested that the appearance of their office reflected leadership's attitude toward them, "It's a little bit disrespectful that it looks so bad."

Burnout modifier: mindfulness

Nature and indoor plants were frequently seen as "grounding" elements and a form of "mindfulness." Three participants attributed indoor plants with mindfulness features for professionals, including the chance to "just be" with the plants. One called plants "grounding . . . [a reminder that] you're going to be alright." Most participants spoke at length about these traits with respect to outdoor nature. "Just being outside, it just grounds you. It takes you back to reality," observed an administrator in the control group. The administrator continued, "Just stepping away from this, you know taking technology away and just being present and taking a breath and just, just being. Grounding yourself, really. Just taking a moment to like, reset is probably one of the most beneficial parts [of nature]."

Burnout modifier: cohesive workplace

Two treatment participants articulated positive effects of the indoor plants on dynamics between coworkers. A clinician in the treatment group said that the plants had boosted chitchat among staff: "They were a great talking point when we would go to the nursing stations, they would be like, 'This plant is doing well today, or this is not.'" Another shared the whimsical anecdote that coworkers had named one of the large philodendrons "Aubrey" and greeted the plant every morning. In contrast, a clinician who was not in the treatment group expressed remorse that their colleagues did not have sufficient access to outdoor nature: "There are a lot of them, particularly primary care providers who probably don't have much time during the week, and only on weekends, to take a moment and be outside. And I suspect if they had a daily exposure of some sort it would, it would have a significant impact [on wellbeing]." When envisioning ideal workplaces, three participants brought up access to nature in the context of social activities, especially a desire for outdoor areas for lunch breaks. One clinician in the clinic associated with a residency thought that holding lectures outdoors would boost morale for faculty and residents. Apart from indoor plants or other forms of nature exposure, relationships with colleagues appeared to play an important role in workplace satisfaction for five participants. Participants in both treatment (2) and

control (2) groups spoke warmly about relationships with colleagues and suggested that these enhanced their wellbeing at work or protected against burnout.

Feasibility

Three participants, two in the control group and one in the treatment group, expressed concern about sanitation or the potential for unsightly dying plants. One participant in the treatment group had noticed wilting plants near their workspace during the study and suggested that the positive impact of the plants diminished when this happened. In contrast, a participant from the other treatment site had noticed a peace lily with fungus gnats but did not think that this reduced the positive effect of the plants. A control participant speculated about adding plants to their office, "While plants can filter air and stuff like that, I feel like there's a general air of uncleanliness if it's cluttered. So you might have a plant or two here or there, but if they died and you don't throw it out . . ." Concern about sanitation was paired with assumptions about which indoor environmental changes their healthcare institution would permit: "I mean, obviously, we know that there's infection control aspects that kind of limit that thing." In contrast, a control participant was emphatic that plants are not sources of contagion: "They keep telling me [plants] would spread germs, and I'm like, how the hell can a plant spread germs?" Some participants wondered about the feasibility of keeping indoor plants alive and pleasant looking over the long term in an office space. However, an administrative worker suggested that many of their colleagues would love to take care of plants if they were added to the office: "I can identify right now at least probably 5 to 7 people who would love to volunteer to take care of the plants--like that would be a highlight of their day."

4. Discussion

Statistical trends in conjunction with qualitative findings from this study suggest that indoor plants have the potential to promote wellbeing and possibly reduce burnout among healthcare professionals. Survey data points to an association between the addition of plants and reduced burnout levels over the course of the two months of surveys (Figure 2). In interviews, treatment participants did

not explicitly link the addition of indoor plants to reduced burnout. However, they did note features of indoor plants that are associated with reduced burnout, pointing to the potential of indirect benefits on burnout and wellness. For instance, indoor plants were associated with wellness indicators of positive mood ("they make you feel good"), reduced anxiety ("it's my way of taking a Xanax") and physical wellbeing ("plants in a room . . . make a world of difference in terms of people's general energy level"). These findings are in keeping with prior literature pointing to stress reduction and improved self-reported physical health in environments with indoor plants, a response that is parallel to the stress reducing and health promoting effects offered by exposure to outdoor nature (Deng and Deng, 2018; Fjeld, 2000; Ulrich, 1993).

Three study sites (one treatment and two controls) started with similar burnout levels. One treatment site, however, was affiliated with a residency program and started with notably lower burnout levels than the others (Figure 3). It is possible that the low burnout levels at this clinic made the addition of indoor plants less impactful. Reasons for low burnout rates at this clinic may have been strong community ties (mentioned by two interview participants), and small panel size for providers (mentioned by one participant), both of which have been shown to be protective against burnout (Eliacin et al, 2018; Paige et al, 2020). In contrast, workers at other sites were likely to mention panel size as a contributing factor to stress and burnout.

Although it was a provider who expressed concern that administration would "throw a lot of these plants at us" to address burnout, surveys suggest that providers may have been the most positively impacted of the three professional groups by the addition of plants (Figure 4). This may have been the result of the layouts of the clinics in this study, in which providers have their own workrooms while nursing stations and administrative desks are centrally located, less private, and less spacious. Provider rooms may have felt less crowded by the addition of plants than the other spaces, allowing providers to be more positively impacted by their presence. Another explanation is that providers tend to work longer hours than other healthcare professionals and thus may experience less exposure to the outdoors during workweeks. The indoor plants may have been a positive proxy for providers. Indeed, Figure 6 suggests

that low NR6 participants were the most positively impacted by the addition of plants. This suggests an important practical application for healthcare professionals who work long hours or who live in urban areas. That said, all interview participants described enjoyment of or connection with nature, a finding that echoed NR6 results, which were skewed toward high nature relatedness (Figure 5). This study did not have a sufficient sample size to evaluate the moderating effect of NR6 in all statistical models.

Literature regarding the effects of either nature or natural element exposure on burnout or the dimensions of burnout is limited. However, a study by Hyvönen et al (2018) of nearly 800 workers found that high exposure to outdoor natural environments during either work or leisure time was associated with reduced workplace negativism and sense of lack of efficacy compared to low exposure to nature. Another study by Mihandoust et al (2021) investigated the effect of perceived exposure to nature during work hours (through window views of nature or artwork featuring nature scenes) and found that increased perceived exposure was associated with lower emotional exhaustion and workplace negativism. In the current study of exposure to indoor plants, trends within the three burnout dimensions were similar to total burnout trends. Thus, it is possible that exposure to indoor plants may impact all three dimensions of burnout, but more research will be necessary to understand this interaction.

As noted, burnout levels stayed steady or decreased over the survey period in most analyses of treatment groups; however, burnout tended to increase during the survey period in most analyses of the control groups. The increase in burnout of the latter groups may be the result of the natural trajectory of burnout, which may worsen over time without effective intervention (Koressel et al, 2020). However, unique factors at the control clinics, survey fatigue, seasonality (the survey period spanned late spring and early summer, which may have incited increased restlessness among indoor workers), the national political environment (for instance, Roe v. Wade was overturned during the study period) may be other reasons behind the increases in burnout observed as particularly acute among control participants. Interviews failed to elucidate potential reasons for the increases observed in the control group.

Although interview participants did not reference burnout as defined by Maslach and Jackson, their descriptions of burnout were closely aligned to this formal definition. Participants spoke poignantly

of emotional and physical exhaustion, negative feelings at work, and feeling unable to accomplish what they desire due to constraints of their jobs. All interview participants described having been burned out at some point in their careers, and about half admitted that they were currently burned out, a finding that was not surprising given national trends in burnout (Murthy, 2022).

In the interviews, indoor plants were strongly associated the concept of home and hominess, which had positive, mood-enhancing connotations. Research suggests that a supportive, low-stress home life is associated with reduced burnout rates among healthcare professionals, especially in women (Asiedu et al, 2018; Verweij et al, 2017). It is possible that the stress reducing effects of indoor plants observed among interview participants had to do with their positive associations with home; alternatively, the association with home may have been a positive attribute of plants that nonetheless played no role or a minimal role in stress or burnout reduction among participants. It is interesting to note that the majority of interview and survey participants were female. However, the two male interview participants also spoke of their associations between indoor plants and home.

The ability of plants to "distract" or offer a form of "escape" was another wellness indicator and indirect benefit of indoor plants on burnout mentioned by interview participants. These observations are in consonance with Kaplan's theory of attention restoration (ART) (1993), which posits that an environment should have the following characteristics to be considered restorative: (1) a softly fascinating quality that captivates attention while allowing for reflection; (2) a sense of being away from one's typical environment; (3) being of sufficient quantity or scope to engage the senses; and (4) compatibility between the environment and one's purposes. In this study, interview data suggested that potted plants may have met three of these four criteria by offering (2) a form of "escape" or sense of "being away," and possibly being of sufficient quantity to engage the senses (3) (there were "plants everywhere," said one treatment participant enthusiastically). It could also be presumed that there was compatibility between the indoor plants and participants' work purposes (4), as no one described the plants as an interference or inconvenience. Interview data does not explicitly point toward the possibility that participants found the plants softly fascinating, a topic that should be explored more in further studies. Participants also spoke of

time outdoors in natural settings using terms that echoed restorative characteristics 2, 3, and 4, although for characteristic 4, compatibility appeared to exist between the environment and participants' recreational, not professional, purposes.

Participants also reflected on positive attributes of indoor plants that are associated with known burnout modifiers. Poor institutional leadership has been associated with greater burnout levels (Shanafelt et al, 2015). In this study, participants at both treatment sites spoke of relations to institutional leadership in the context of the added plants: one suggested that the plants had made workers feel more "seen" and respected by leadership, while the other felt initial distrust upon seeing the plants, thinking that leadership had "thrown" plants at workers to address burnout—a feeling that shifted to delight upon hearing that office workers were not responsible for the plants' maintenance. It is therefore possible that the addition of plants may have offered a small boost to workers' perceptions of their organization's leadership. Participants also expressed desired changes to their work environment that would allow for more time outdoors, such as outdoor benches and gardens. At the same time, participants reported skepticism about leadership's willingness to enact these changes, suggesting current dissatisfaction with leadership that could be improved with biophilic interventions.

Another burnout modifier mentioned by participants in the context of indoor plants is mindfulness. Research suggests that the combination of nature, restorative environments and mindfulness can have strong positive effects on work-related stress (Mendardo et al, 2022). It is possible that plants in office spaces could promote wellness through mindfulness opportunities, as some interview participants suggested. Time outdoors in nature was also often attributed with mindfulness promoting qualities. Some therapeutic modalities, such as shinrin-yoku ("forest bathing") and nature-based therapy have seized the potentially synergistic effects of mindfulness and time outdoors (Harper et al, 2021). A study by Daniels et al (2022) found that a nature-based intervention for workers in a range of professions could reduce burnout and physiologic signs of stress and improve cognitive processing speed. This intervention was time consuming (two hours twice a week for three weeks), and an intervention of this scope may not be realistic in healthcare, particularly in primary care settings. However, it does suggest that nature-based

interventions are promising ways to enhance wellness among workers, a sentiment echoed by many interview participants.

Workplace cohesiveness is another burnout modifier observed in literature and noted in the context of indoor plants. The indoor plants appeared to inspire lighthearted banter (e.g., workers giving a human name to at least one plant) and conversation between different professional groups. Other participants expressed desire for modifications to the outdoor work environment such as benches and gardens to allow for outdoor learning activities or socialization during lunch breaks. Research has shown that cohesive work teams can be a protective factor in burnout, and that nature can promote prosocial behavior and social capital (Eliacin et al, 2018; Castello et al, 2021; Beames and Atencio, 2008). Future research should further explore potential connections between workplace cohesiveness and indoor plants or other biophilic elements in the workplace.

This research, as with most research involving the psychological health effects of indoor plants, presumes that some of the health promoting effects of indoor plants has to do with their role as an element of nature, which, as noted throughout this text, has been shown to have wide-ranging beneficial effects on human mental and physical health. The theories of SRT, ART and biophilia may be compelling explanations behind the positive effects of (outdoor) nature on humans, but it would be a fair objection on the part of a reader to assert that these theories do not sufficiently explain the effects observed in potted plants. Potted plants, such a reader might argue, are not, in fact, natural, as they have been bred, domesticated, curated, and designed into forms and spaces that dramatically differ from what are typically considered natural. Thus, the evolutionary link between nature and human health may not relate, or may relate differently, to indoor plants. Indoor plants may be metaphors for nature, eliciting similar responses to nature in humans without being truly natural elements themselves. Or as Bringlismark (2009) has suggested, cultural expectation or acclimatization, rather than biological evolution, may be the primary element contributing to the beneficial effects of indoor plants. In other words, indoor plants may have an association with mindfulness, hominess, or another wellness archetype distinct from "nature" that elicits positive sentiment. Interviews in this study suggested that the association with home was a positive

feature of indoor plants for both control and treatment participants; future research will need to elucidate the relative impact of this connection, compared to other associations or attributes of indoor plants.

Another form of cultural expectation or acclimatization of indoor plants may relate to social status. Historically, both indoor and outdoor plants have served as status symbols: while *Brugmansia* entertained Victorian elite with its gently psychotropic effects, window boxes filled with red pelargoniums became a symbol of the working class, eventually growing so prosaic that designer Gertrude Jekyll had to defend their presence in her garden (Horwood, 2020). Today, indoor plants continue to hold similar sway in the western cultural psyche (Horwood, 2020). As primary care specialties are often seen as the least prestigious within healthcare, it must be asked: could the addition of indoor plants be interpreted as an elevation of the status of beleaguered, underappreciated primary care workers? (Ephgrave, 2011). As one treatment participant noted, the appearance of "appreciation" by the larger healthcare organization may have boosted morale for workers in that office, arguably a small form of status elevation. (Participants were not told that the plants were related to a study during the survey period, so some may have assumed that their organization had given them as gifts). On the other hand, it is possible that the benefit of indoor plants in this study had nothing to do with plants and their associated symbolism, but rather their role as perceived gifts by the institution. Perhaps the addition of artwork, new technology, or even a new water cooler (noted by a control participant as a positive attribute of their office environment) could elicit similar effects as observed of plants in this study.

Our research focuses on passive interaction with plants because such interaction is a practical application for healthcare. Some institutions may be able to incorporate or encourage more active forms of involvement with houseplants, such as indoor horticultural therapy. It is likely that these forms of engagement could reap greater rewards for mood and worker wellness, since studies comparing active and passive involvement with indoor plants suggest that active engagement yields more positive rewards (Han, 2018). The control participant who was an avid indoor gardener exemplifies this. As they said, "my way of [staying calm] is my plants." However, most participants in our study emphasized the busyness of their workdays, making active engagement with plants at work appear less feasible than passive

engagement. Other concerns around feasibility brought up by study participants include maintenance of the plants, particularly in caring for or removing diseased or dying plants. A dead or dying plant, as some participants pointed out, may have negative impacts on wellbeing. The risk of negative impacts of plants on workers' mood, particularly in cases of poor maintenance, should be considered by healthcare organizations before making environmental changes. That said, it is interesting to note that maintenance concerns were more commonly mentioned by control participants, suggesting that most treatment participants did not observe major flaws in maintenance. Outside of a study such as this, an interior plant maintenance program may cost $1200 to $7200 annually for a large office (Hoffman Design Group, 2021). In contrast, the average cost of turnover for a bedside nurse (RN) is $40,038, and since 2016, the average hospital has turned over 83% of its nursing staff, equating to about $5 million lost per hospital every year (Plescia, 2021).

Study Limitations and Future Directions for Research

Our sample size (clinic n = 4) was a notable limitation to the statistical aspect of this study and likely contributed to our inability to conclude statistical significance and evaluate our data using NR6 as a moderator in all models. The high degree of variance attributed to participant ID is another indicator of the need to increase sample size of both clinics and participants, and, if possible, to trace individual responses over time, since it suggests that much of the survey variance was attributable to individual preferences and behavior. As a pilot study, our work benefited from a qualitative component that allowed us to better understand influences of burnout, modifying effects of nature on burnout, ideal workplace design for wellness, and, for participants in the treatment group, their experiences with the plant treatment.

Another limitation of this study is its lack of blinding. Participants were not informed about the nature of the study by our research team during the treatment period; however, the addition of plants in conjunction with surveys likely hinted at the nature of the study to participants. As Han et al (2022) point out, it is difficult for researchers investigating the psychological benefits of plants to create fully blinded

studies, since treatment necessitates interaction with plants. Furthermore, although the clinical sites we selected consisted of similar specialties and provider FTE, and although all four clinics were part of the same health system, each clinic had variability that could not be controlled. Observed variability included physical layout (including natural light levels), management styles and staff personalities, and the presence of trainees (residents), which may have influenced clinic dynamics.

All clinics experienced staff and managerial turnover during the study period, too. These factors probably contributed to a lower-than-ideal survey response rate (particularly among clinical support staff) and may have impacted burnout levels and response to treatment, although we were not able to observe discernable patterns since all clinics reported high turnover. These factors are also elements of in-vivo research that are difficult to avoid and should be addressed through larger sample sizes.

Future studies should include a larger number of clinics and ensure that each participant completes multiple surveys, thus enhancing statistical power and allowing analysis of individual changes in addition to group changes over time. This is difficult to do given the high workload of healthcare professionals. Our team tried to incentivize survey follow-through for all participants of Survey 1, but we were less than fully successful. However, completion of multiple surveys by the same participants could be enhanced through more desirable survey incentives and more consistent encouragement by managers, which was limited in our study due to managerial turnover. Future studies should consider a longer treatment duration, as burnout is conceptualized as a long-term phenomenon (Demerouti et al, 2002; Maslach, 2001). Future studies could work with healthcare institutions to design living walls or hanging baskets of plants, which would pose less risk of interfering with workflow or creating a cluttered appearance. Subsequent studies should also explore the impacts of varying sizes of plant, types of plants, and quantity of plants, to maximize beneficial effects for workers.

Conclusion

The burnout epidemic, as the American Medical Association has coined it, poses high risk to healthcare systems. Burnout can increase absenteeism, staff turnover, have negative implications for professionals'

personal lives including an increased risk of anxiety and depression, lower patient satisfaction and endanger patient care (De Hert, 2020). Our results suggest that modifications to the built environment in the form of indoor plants could enhance wellness, as described by treatment participants who noted enhanced mood and appreciation of the plants, and could contribute to burnout modifiers such as mindfulness and workplace cohesiveness. Survey data suggests that indoor plants may reduce burnout, particularly among providers and people with low self-perceived connection to nature. More robust studies are needed to confirm these findings and uncover the extent and means by which indoor plants can contribute to workplace wellness.

We wish to acknowledge the concern that some participants had about "quick fixes" to the burnout epidemic. Healthcare organizations should not view nature-based interventions as the primary way to address bumout, but rather as one tool among many to improve workplace wellness. As multiple interview participants pointed out, systemic issues of workload, staffing, and insurance reimbursement are core drivers of medical burnout and need to be addressed in conjunction with other means to promote wellness. Nonetheless, interventions promoting restorative environments, including indoor plants, can be low-cost means to enhance worker wellness in a famously high-strain profession. As one interview participant observed, "What little you do for [a plant], it does a lot for you."

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