Nature Sacred

Take Burnout from Red to Green

New calculator provides custom estimate of how much hospitals can save on burnout related expenses by investing in accessible green spaces.

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The Burnout Effect

Introduction

US health institutions are struggling under the weight of a host of challenges that are impacting the very health of the institutions themselves—and their ability to provide the best possible care to patients.

The World Health Organization defines burnout as a syndrome "conceptualized as resulting from chronic workplace stress that has not been successfully managed and characterized by three dimensions"[1]:

- Feelings of energy depletion or exhaustion
- Increased mental distance from one's job, or feelings of negativism or cynicism related to one's job
- Reduced professional efficacy

While multiple market, workplace, and society-based factors are at play, many of these challenges are both a cause and result of burnout of health care providers—namely doctors and registered nurses (RNs).[2]

Excessive workloads,[3] clerical responsibilities, inefficient work practices, and work–home conflicts have repeatedly been identified as being factors driving higher rates of stress and burnout among physicians. Among RNs employed in hospital settings, the most prevalent drivers of burnout are, as with physicians, workload; and, emotional strain.

While hospital and health care leaders look to better understand and find ways to address these root causes of burnout, one intervention, radical in its simplicity, has been proven to help alleviate the symptoms of stress and burnout in hospital settings: nature. Coupled with other actions to address systemic issues fueling stress and burnout, green spaces should be considered as

1 *ICD-11. (n.d.-c). Retrieved February 19, 2022, from https://icd.who.int/en*

2 *Shah, M. K. (2021). Prevalence of and factors associated with nurse burnout in the US. JAMA Network Open, 4(2), e2036469–e2036469. https://doi.org/10.1001/jamanetworkopen.2020.36469*

3 *West, C. P., Dyrbye, L. N., & Shanafelt, T. D. (2018). Physician burnout: Contributors, consequences and solutions. Journal of Internal Medicine, 283(6), 516–529. https://doi.org/10.1111/joim.12752*

part of a multi-pronged approach to creating a work environment where physicians and nurses can thrive.

Scientists have repeatedly published on biophilic interventions—interventions that connect people with nature—and their association with a number of benefits in health care settings largely believed to result from a reduction in stress.[4] Studies have defined biophilic interventions in different ways—from a view of a natural scene from a hospital room bed[5] to a hospital garden.[6] At the same time, we know from other studies that the impacts of burnout are costly, in terms both of the personal toll it takes on health care workers' personal and professional lives and the concomitant financial burden on hospitals.

Designing hospitals to reduce stress is not a novel concept. Take Nationwide Children's Hospital in Columbus, Ohio, for example. But the focus of this design, intended to encourage calm—to provide a "mental getaway" while being treated—has been children and parents. A logical next step is to extend this kind of thinking to staff.

Hospitals like Legacy Health in Portland, Oregon, and Johns Hopkins Bayview Medical Center in Baltimore, Maryland, have installed hospital gardens specifically because they connected the dots, recognizing the green spaces as smart investments for patients, families—and staff. They did this without having any hard numbers in hand enumerating the financial value of their green spaces.

The million dollar question, literally: Just how much might a given hospital save if it were to invest in a usable green space? Until now, we have had no means to arrive at such a figure.

Now, we can answer that question. Health economist Sean M. Murphy, PhD, of Weill Cornell Medical College, worked with Nature Sacred to create a customizable budget impact tool—a calculator—for the purpose of estimating the economic costs incurred by hospitals as a result of burnout, as well as the costoffsets associated with biophilic interventions. Empirical evidence exists to support the benefit of nature in health care settings to both providers and, to a smaller extent, patients. Both were used to inform this calculator.

This is the first such tool designed to estimate both the annual costs incurred by hospitals as a result of provider burnout and the costoffsets that could be realized by incorporating biophilia into their architectural design.

4 *Ulrich, R. S., Cordoza, M., Gardiner, S. K., Manulik, B. J., Fitzpatrick, P. S., Hazen, T. M., & Perkins, R. S. (2019). ICU patient family stress recovery during breaks in a hospital garden and indoor environments. HERD: Health Environments Research & Design Journal, 13(2), 83–102. https://doi.org/10.1177/1937586719867157*

5 *Ulrich RS. View through a window may influence recovery from surgery. Science. 1984 Apr 27;224(4647):420-1. doi: 10.1126/science.6143402. PMID: 6143402.*

6 *Cordoza, Ulrich, Manulik, Gardiner, Fitzpatrick, Hazen, Mirka, Perkins, Impact of Nurses Taking Daily Work Breaks in a Hospital Garden on Burnout. (nnn*

The Situation

Burnout among nurses and doctors is pervasive

In 2019, health care leaders across the country named financial barriers, personnel shortages, and behavioral health/addiction issues as their greatest challenges.[7] Then came the onslaught of COVID—and new and unprecedented stress and strain on staff and revenues. The following key figures, used in the development of the calculator, and captured prior to 2020, speak to the high prevalence of burnout among health care providers, even before the COVID-19 pandemic.

BURNOUT STATS

Nurses

31%

of nurses who were leaving their jobs did so because of burnout.

43%

of nurses reported considering leaving their profession due to burnout.[9]

51%

of nurses were experiencing burnout that exceeded the norms for health care workers.[8]

Doctors

up to 54%

of doctors experienced burnout.

79%

of primary care providers experienced burnout.

7 *Top issues confronting hospitals. (n.d.). American College of Healthcare Executives. Retrieved January 22, 2022, from https://www.ache.org/learning-center/research/about-the-field/top-issues-confronting-hospitals*

8 *Reith, T. P. (2018). Burnout in United States healthcare professionals: A narrative review. Cureus, 10(12), e3681. https://doi.org/10.7759/cureus.3681*

9 *Shah, M. K. (2021). Prevalence of and factors associated with nurse burnout in the US. JAMA Network Open, 4(2), e2036469–e2036469. https://doi.org/10.1001/jamanetworkopen.2020.36469*

Post 2020, multiple surveys have been conducted in an attempt to measure the levels of burnout and stress that many observed were increasing as hospital intensive care units swelled with COVID patients. They have consistently and repeatedly shown alarmingly high levels of mental health strain among nurses and physicians; the COVID pandemic has exacerbated what was already a troubling and entrenched problem.

Measuring the toll and cost of burnout

The effects of stress and burnout can and do ripple through both the personal and professional lives of the people directly experiencing it[10] and, naturally, throughout the institutions in which they work. Burnout can exacerbate symptoms of anxiety and depression and, in the most extreme cases, even suicidal behavior,[11] which was already more common among physicians than among the general public.[12]

From an organizational perspective, burnout has been directly linked to reduced workplace productivity—for instance, in the number of patients seen and number of elective procedures performed—medical error; and staff/provider absenteeism and turnover—all of which culminate in a significant financial liability risk and cost for hospitals that is estimated to be in excess of $4 billion **annually.**[13]

The cost of replacing a physician has been calculated to amount to two to three times their salary.[14] For nurses, that figure lands at roughly $16K per nurse, per year in on burnout-related turnover costs.[15] Consider these figures in light of the alarming resignation trend among both physicians[16] and nurses,[17] with one in five doctors planning to leave their current practice within five years and the 2021 turnover rate for bedside nurses having climbed to 18.7%.[18]

10 Hurt, A. (2022, January 21). Physician burnout, depression compounded by COVID: Survey. Medscape. https://www.medscape.com/viewarticle/966996#vp_2

11 Menon, N. K., Shanafelt, T. D., Sinsky, C. A., Linzer, M., Carlasare, L., Brady, K. J. S., Stillman, M. J., & Trockel, M. T. (2020). Association of physician burnout with suicidal ideation and medical errors. JAMA Network Open, 3(12), e2028780. https://doi.org/10.1001/jamanetworkopen.2020.28780

12 Kalmoe, Molly C et al. "Physician Suicide: A Call to Action." Missouri medicine vol. 116,3 (2019): 211-216.

13 Han, S., Shanafelt, T. D., Sinsky, C. A., Awad, K. M., Dyrbye, L. N., Fiscus, L. C., Trockel, M., & Goh, J. (2019). Estimating the attributable cost of physician burnout in the United States. Annals of Internal Medicine, 170(11), 784. https://doi.org/10.7326/m18-1422

14 Han S, Shanafelt TD, Sinsky CA, et al. Estimating the attributable cost of physician burnout in the United States. Ann Intern Med. 2019;170(11):784-790.

15 Moran D, Wu AW, Connors C, et al. Cost-benefit analysis of a support program for nursing staff. Journal of patient safety. 2020;16(4):e250-e254.

16 Association, A. M. (2022, January 18). Medicine's great resignation? 1 in 5 doctors plan exit in 2 years. American Medical Association. https://www.ama-assn.org/practice-management/physician-health/medicine-s-great-resignation-1-5-doctors-plan-exit-2-years

17 Association, A. M. (2022, January 18). Medicine's great resignation? 1 in 5 doctors plan exit in 2 years. American Medical Association. https://www.ama-assn.org/practice-management/physician-health/medicine-s-great-resignation-1-5-doctors-plan-exit-2-years

18 Why so many nurses are quitting (and what to do about it). (n.d.). Advisory Board. Retrieved April 16, 2022, from https://www.advisory.com/daily-briefing/2021/10/06/nurse-turnover

Far exceeding turnover costs though, are those related to medical liability; most specifically, defensive medicine. For this report, we dug into previously published studies on the probability of physician burnout being associated with malpractice suits, and the related costs—from indemnity payments, administrative expenses, and workdays lost for the physicians involved to defensive medicine. Defensive medicine, defined as the practice of ordering tests, procedures, and other medical care solely to reduce the threat of malpractice liability, are by far the largest driver of costs associated with burnout in our model, accounting for almost 80% of the annual estimated costs associated with burnout.

Physicians experiencing burnout

- Correlates with an increase in medical errors[19]
- Negatively impacts recovery times of patients in their care

> **"Burned-out doctors are twice as likely to have patient complaints from the ombudsman and complaints of unprofessional behavior."**
>
> – *Dr. Tait Shanafelt, M.D., chief wellness officer, Stanford Medicine.*[20]

ABBREVIATING LENGTH OF STAY FOR PATIENTS

While the primary focus of this paper is nature's impact on nurses and physicians, its impact on patients was also briefly explored. Included in our calculator are data pertaining to the influence of biophilic design on patient length of stay in hospital. Even a view of a tree through a hospital room window has been shown to decrease both the length of post-operative hospital stay and complications.[21] Patients hospitalized with bipolar disorder and depression who are placed in sunny rooms filled with natural light, compared to artificially lit rooms, also spend fewer days in the hospital.[22] Among the benefits of shorter hospital stays: better patient health outcomes, greater patient satisfaction with their overall hospital experience—and cost savings for hospitals.[23]

19 *Shanafelt TD, Balch CM, Bechamps G, Russell T, Dyrbye L, Satele D, Collicott P, Novotny PJ, Sloan J, Freischlag J. Burnout and medical errors among American surgeons. Ann Surg. 2010 Jun;251(6):995-1000. doi: 10.1097/SLA.0b013e3181bfdab3. PMID: 19934755.*

20 *Ostrov, B. F. (2018, August 7). Stanford's chief wellness officer aims to prevent physician burnout. Fierce Healthcare. https://www.fiercehealthcare.com/practices/stanford-s-chief-wellness-officer-aims-to-prevent-physician-burnout*

21 *Ulrich, View through a window may influence recovery from surgery. (n 5)*

22 *Beauchemin, K. M., & Hays, P. (1996). Sunny hospital rooms expedite recovery from severe and refractory depressions—PubMed. Journal of Affective Disorders, 40(1–2). https://doi.org/10.1016/0165-*

23 *Baek, H., Cho, M., Kim, S., Hwang, H., Song, M., & Yoo, S. (2018). Analysis of length of hospital stay using electronic health records: A statistical and data mining approach. PLoS ONE, 13(4). https://doi.org/10.1371/journal.pone.0195901*

A Solution

Radical in its simplicity

Scientists, including physicians, have amassed an immense body of work in recent decades empirically supporting nature's unique ability to have a robust impact on human health in a plethora of ways. For instance, time spent in nature has been shown to decrease feelings of depression, improve overall feelings of well-being, and reduce levels of mental fatigue—the state of exhaustion caused by prolonged periods of focused cognitive activity. It also reduces heart rate, blood pressure, and other physiologic markers of stress.[24] At this point, we are increasingly seeing this knowledge intentionally applied—and in specific settings, like hospitals, to address specific issues, like burnout.

Pioneering researchers, such as Roger Ulrich, PhD, are working to gain a more nuanced understanding of nature's efficacy in very specific contexts. Ulrich, a noted health care design researcher and expert, has spent decades studying nature's explicit impact in health care settings, observing how it influences everything from patient recovery time to burnout in nurses. The latter was the subject of a prospective crossover trial conducted at a level 1 trauma center in Portland, Oregon.[25] Nurses were randomly assigned to either six weeks of taking their daily work break in the hospital's therapeutic garden and then six weeks of work breaks indoors, or vice versa. Using the most common measure of burnout in health care settings, the Maslach Burnout Inventory, the authors found a significant reduction in the emotional exhaustion score among those nurses who had spent their break times in the garden.

This study, combined with more than two dozen others reviewed by Dr. Murphy, played a key role in the development of the budget impact tool.

Staff enjoying a break in their outdoor garden space, a "Sacred Place", at Legacy Emanuel Medical Center in Portland, Oregon.

24 *Nature Sacred. The Healing Power of Nature; How Green Space is Improving Health and Wellbeing in Cities. www.naturesacred.org. 2019.*

25 *Cordoza M, Ulrich RS, Manulik BJ, et al. Impact of nurses taking daily work breaks in a hospital garden on burnout. American Journal of Critical Care. 2018;27(6):508-512*

Crunching the Numbers

Green spaces as a lifesaving, cost-saving investment

CREATING THE CALCULATOR

As already referenced, an extensive body of research exists on the health benefits of nature and, separately, on the health and economic impacts of burnout among health care providers. Dr. Murphy, using a health economics lens, reviewed the existing literature in both domains gathering those studies conducive to estimating burnout-related costs, as well as offsets related to access to nature, associated with turnover, absenteeism, and medical liability. Biophilia-related cost offsets were also identified in length-of-stay reductions associated with certain inpatient services. The information he gathered provided the building blocks for the calculator.

Specifically, this tool can be used by a hospital to estimate the following:

a. The excess costs resulting from burnout incurred according to its effect via increased physician/nurse turnover, work-effort reduction, and medical liability risk;

b. The potential cost offsets associated with a nature-based intervention through its reduction in the aforementioned burnout-related costs, and reduced patient lengths of stay for various admission types (page 6);

c. The annual net benefit/cost of the intervention following a hypothetical Year 1 in which both the fixed (i.e., one-time) construction costs, and the annual maintenance costs of the intervention are incorporated into the hospital's budget; and

d. The net value of the intervention in subsequent years, when only the maintenance costs must be accounted for.

What's your number?

This calculator can be used by any hospital to estimate the potential economic value of investing in a hospital green space. The following key inputs are required for a hospital to calculate its customizable estimates of costs and benefits. A full methods section is available at the end of the report.

Calculator for potential economic impact of hospital green space	
# of primary care physicians employed	
# of physicians in surgical specialties employed	
# of physicians in other specialties employed	
# of RNs employed	
Cost of creating your green space (your budget estimate)	$
Expected annual maintenance costs of the green space	$

These inputs can all be entered for a customized estimate, or the user can simply enter the anticipated number of primary care physicians, and the calculator will automatically generate the remaining input values according to findings from the literature.

To bring the calculator to life here, we offer two hypothetical, but realistic, scenarios: one, a small hospital; the other, a large health facility.

In these examples, we assume that the hospitals choose to build a garden space, similar to the one described above from the nurses study,[20] but one is available to both patients and hospital employees. Based on previous Nature Sacred projects to create hospital green spaces, including the one that served as the site for the nurses study, we know that these costs can range broadly. For this example, we assume the cost to build a garden sufficient to comfortably accommodate access by all (i.e., patients, visitors, providers, etc.), is $500,000 for the small hospital scenario, and $950,000 for the large hospital. Annual costs required to maintain the gardens are estimated as: $20,000 and $30,000, respectively. **Very important to note here:** many factors impact the cost of maintenance (the size of the green space, the inclusion of a water feature, types of plants and trees used, geographical region), and there are likewise many design strategies that can be employed to minimize maintenance costs, all of which would vary by hospital.

20 *Ostrov, B. F. (2018, August 7). Stanford's chief wellness officer aims to prevent physician burnout. Fierce Healthcare. https://www.fiercehealthcare.com/practices/stanford-s-chief-wellness-officer-aims-to-prevent-physician-burnout.*

Use our calculator to find out how much your hospital could save:

www.naturesacred.org/calculator

Applicable to both urban and rural settings

SCENARIO A

A small hospital

Primary care physicians: 4

Surgical specialty physicians: 7

Other specialty physicians: 2

Full-time nursing staff: 100

Invests in green space:

$500,000 (initial construction)
$20,000 annually (maintenance)

Estimated annual net benefit in year one after installing a hospital green space used by your physicians and nurses: ***~ $1.6 million***

SCENARIO B

A large health facility

Primary care physicians: 19

Surgical specialty physicians: 25

Other specialty physicians: 45

Full-time nursing staff: 950

Invests in green space:

$950,000 (initial construction)
$30,000 annually (maintenance)

Estimated annual net benefit in year one after installing a hospital green space used by your physicians and nurses: ***~ $13 million***

Note: The estimates used here are based on ranges derived from real-world examples.

ADDITIONAL CONSIDERATIONS

By far, the biggest driver of costs associated with burnout in the calculator shared in this paper, is medical liability, most specifically, defensive medicine. Consequently, these costs also represent the area with the highest potential return on nature interventions. Given the extreme difficulty of capturing the many ways in which provider burnout can penetrate an institution and generate additional costs, the estimate of burnout-associated costs can likely be considered a lower bound. **The potential impact of green spaces on other economic drivers, including patient satisfaction and the likelihood that patients will recommend the hospital, are further indications that estimated savings reported in this calculator should be considered a conservative estimate**.

Conclusion

In sum: nature spaces offer a plethora of documented, wide-ranging benefits, from stress mitigation to improved cognitive performance; making them available in a hospital setting can help address the acute and costly issue of burnout among health care workers.

Some hospitals, even the nation's flagship military hospital, are investing in these on-campus biophilic interventions. While these decisions have previously been made based on the science surrounding the health benefits, until now, any estimations of the financial implications were based on inference.

With this new budget impact tool in hand, hospital leaders have the evidence they need to make data-driven decisions to incorporate green spaces into their strategies for improving the health of caregivers and patients—and provide financial benefits to the institutions themselves.

Visualizing

Therapeutic green spaces in hospital and health care settings

Hospital green spaces can take many shapes and forms, and they can be designed for distinct hospital populations and purposes. To illustrate this, we have compiled a cluster of examples of hospital gardens like those referenced in this paper. These green spaces are also what Nature Sacred calls Sacred Places in that they were intentionally designed to promote a sense of peace and wellbeing.

Legacy Emanuel Medical Center

Portland, Oregon—Level 1 Trauma Center

Landscape design by *Quatrefoil, Inc.*

The 6500-square-foot suspended green space is connected to the Family Birth Center as well as the Cardiovascular ICU and family waiting rooms and is accessible around the clock to all hospital patients, visitors, and employees. It was designed to accommodate a wide range of physical conditions, abilities, and needs.

Amid its four-seasons array of plants that are ever-changing are benches, chairs, and tables configured to accommodate groups or provide privacy. With the benefit of a canopy of mature trees, The Terrace Garden offers a unique treetop experience.

Additionally, the Terrace Garden has served as a site for research into the relationship between nature and human health. Studies here have focused on the role nature can play in the birth experience of laboring mothers and families; and on nature as a means to combat stress and burnout among nurses.

The terrace is used every day for a variety of wellness events for staff and visitors, including horticulture and pet therapy programs.

Johns Hopkins Bayview Medical Center

Baltimore, Maryland—Teaching Hospital and Trauma Center

As one of the top medical facilities in the country, located in the heart of Baltimore, staff, patients, and visitors are primed to benefit from all that the Healing Garden there has to offer. And they frequently do.

The space includes a labyrinth, which has been a draw to patients, staff, and the community. The hospital actively encourages patients, staff, and their family members to walk the labyrinth as a means to address stress, and provides them with a guide.

The hospital's director of spiritual care frequently uses the garden and labyrinth with patients and families, incorporating the healing power of nature into her chaplaincy work.

The Green Road at Walter Reed Military Medical Center

Bethesda, Maryland | *The nation's largest and most renowned joint military medical center*

Landscape design by *University of Maryland Landscape Architecture Department*

In addition to benefiting the immediate community, the hospital greenspace has a ripple effect that touches the pride of the nation and is helping to launch military research forward.

The Green Road at Walter Reed National Military Medical Center is built on a woodland section of the campus. The space surrounds “Wounded Warriors”—men and women in the US military wounded during operations—and their families with the healing powers of nature in an oasis of respite and combines a healing, patient-centered approach with rigorous data on what works to improve the health of veterans.

Research, ongoing at this site, is working to better understand how nature exposure could be a means to address some of the most intractable health problems the military is facing, including PTSD and traumatic brain injury.

ABOUT SEAN M. MURPHY

Sean M. Murphy, PhD, is associate professor of population health sciences at Weill Cornell Medical College, and a health economist/econometrician by training. Dr. Murphy’s primary work focuses on the management of substance use disorders and related conditions. His research interests more broadly reflect his objective of informing health care stakeholders at all levels, of means by which their resources (labor, materials) could be used more efficiently to simultaneously improve their own well-being and, ultimately, provide evidence-based treatment to the largest number of those in need.

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Following are the foundational research methods and analysis that were the basis for this white paper.

Research Methods & Analysis

Background

Biophilic interventions have been associated with a number of benefits in health care settings, largely believed to result from a reduction in stress.[1-3] However, to-date, little-to-no information exists on the economic value of biophilic interventions from a hospital perspective. Although the cost of a particular intervention may be determined with great certainty, the downstream benefits/cost offsets are quite difficult to estimate.

The primary stress-related concern in the health care sector is provider burnout.[4,5]

The objective of this study was to create a customizable budget impact tool for the purpose of estimating the economic costs incurred by hospitals as a result of burnout, as well as the cost offsets associated with biophilic interventions. Subsequent sections below will describe the creation of the tool, including the selected inputs and relevant assumptions; the process by which the tool estimates costs and cost offsets; and the strengths and limitations.

Methods

OVERVIEW

To begin, a comprehensive review of the existing literature on biophilia was conducted, with specific foci of: a) biophilia interventions in health care settings; b) their effect sizes; and c) the mechanism of action. Information from the literature review informed the structure of the budget impact tool, and provided necessary inputs. All monetary values were converted to 2020 US dollars using the Consumer Price Index.[7] Analyses were conducted in Microsoft Excel.

MECHANISM OF ACTION

Upon review of the literature pertaining to biophilia in health care settings, it was determined that the benefits of biophilia come largely from the reduction of stress, more specifically "burnout", among health care providers. Moreover, of the factors discussed above as being susceptible to provider burnout, and thus additional costs, the following areas were identified as having published, peer-reviewed findings conducive to estimating burnout-related costs as well as biophilia-related cost offsets: turnover, absenteeism, and medical liability. Biophilia-related cost offsets were also identified in length-of-stay reductions associated with certain inpatient services, described below.

BURNOUT

The most common measure of burnout in health care settings has long been the Maslach Burnout Inventory (MBI), a reliable and valid instrument.[6] The MBI measures burnout across 3 domains: emotional exhaustion, depersonalization, and personal accomplishment. An individual is commonly considered to be burned out if their emotional exhaustion (EE) score is ≥27 and/or depersonalization score is ≥10).

MEASURES

Burnout Prevalence

The prevalence of provider burnout was acquired from Han et al.,[8] who estimated burnout for the following nationally representative physician types, according to the U.S. American Medical Association Physician Masterfile: primary care, surgeons, other specialists. The prevalence of nurse burnout was obtained from Cimiotti et al.[9]

Turnover and Absenteeism

Numerous studies have found an association between provider burnout and intentions to either leave the organization, or reduce hours of work; however, few have examined the likelihood of these events actually occurring.[4,8] The following inputs needed to quantify the costs and cost offsets related to burnout-induced turnover and absenteeism were obtained from, or estimated using information provided by Han et al.,[8] according to the previously mentioned physician types, where possible: proportion with burnout who leave their job; probability that the turnover is due to burnout; proportion with burnout who intend to reduce work hours in the next 12 months; probability of reducing work hours, given intention to do so; average reduction in clinical hours associated with burnout; cost associated with physician replacement (searching, hiring, training); and the average, direct revenue loss resulting from the absence of a physician's services.

Other than the estimated cost of nurse turnover,[10] we were unable to find comparable inputs associated with nurses; therefore, physician figures (averaged across physician types where possible) were applied to the number of estimated nurses with burnout, with the exception of revenue lost due to physician vacancy.

The marginal effect that a change in the EE scale would have on the likelihood of turnover and FTE reduction was obtained from Windover et al.[11] and Shanafelt et al.,[12] respectively. Nationally representative measures of mean physician and nurse salaries, fringe benefit rates, and hours worked per week, were obtained from the Bureau of Labor Statistics.[13,14]

Medical Liability

The probability of physician burnout being associated with a malpractice suit was obtained from Balch et al.[15] The following information was either gathered, or directly estimated by Mello et al.[16]: a) annual, national medical liability system costs, per malpractice claim, according to indemnity payments, administrative expenses, and defensive medicine costs; and b) a range of the median number of physician workdays lost due to a malpractice suit. Indemnity payments, as the name suggests, reflect the compensation paid to malpractice plaintiffs; administrative expenses include legal expenses incurred by both malpractice plaintiffs and defendants, as well as insurer overhead; and defensive medicine costs represent expenses resulting from medical services ordered with the intention of reducing a provider's liability risk.

The percentage of liability claims resulting in payment was obtained from Carroll et al.[17] The probability of burnout resulting in a perceived medical error was obtained from Shanafelt et al.,[18] as was the marginal effect that a change in the EE scale would have on the likelihood of a perceived medical error. We were unable to find an estimate for the effect that a change in EE would have on the likelihood of a malpractice suit occurring, at the margin; therefore, the marginal effect for a perceived medical error[18] was also used for this purpose.

The median cost of a medical error to the hospital was estimated by David et al.,[19] and represents the direct medical costs incurred by the hospital for such cases, relative to cases without an error.

Effectiveness: Provider Effects

The primary marginal benefit associated with biophilia, as it pertains to provider burnout, was obtained from Cordoza et al.,[20] who conducted a prospective crossover trial, where nurses were randomly assigned to either 6 weeks of taking their daily work break in the garden, then 6 weeks of work breaks indoors; or vice versa. The authors found a significant reduction in the EE subscale of the MBI associated with garden breaks; on average, the intervention resulted in a 4.7 (95% CI: 2.1, 6.8) point decrease in EE. This estimated effect was applied to both nurses and physicians, as comparable marginal effects were not available for physicians.

Effectiveness: Patient Effects

Benedetti, et al.[21] estimated that hospital length of stay was reduced by an average of 3.7 days among participants admitted with bipolar disorder and assigned to hospital rooms that received a relatively large amount of sunlight, compared to those assigned to rooms that received relatively little sunlight. Similarly, Beauchemin et al.[22] estimated a reduction in length of stay of 2.6 days among participants admitted to the hospital with depression and assigned to rooms that received a relatively large amount of sunlight, versus those assigned to rooms that received relatively little. And Urlich[23] found an average reduction of ¾ of an inpatient day following gallbladder surgery among participants assigned to rooms with a view of a natural setting, compared to those assigned to rooms with a view of a brick wall.

The number of gallbladder surgeries per general surgeon was calculated using the number of gallbladder surgeries conducted in the United States in 2018,[17] and the number of United States general surgeons in 2019 who were involved in patient care.[24] Similarly, the number of depression and bipolar inpatient stays per psychiatrist in the US was estimated using the number of such stays in 2016,[25] and the number of US psychiatrists in 2017 who were involved in patient care.[24] The national average cost of a hospital inpatient stay was previously estimated by Murphy et al.[26]

Analysis

A budget impact tool was created to estimate both the annual cost to hospitals that is associated with burnout among physicians and registered nurses, and the potential cost offsets resulting from a biophilia intervention. As mentioned above, the existing literature not only informed the structure of the tool, but also provided the inputs needed to estimate both the costs associated with burnout, and the cost offsets associated with biophilia.

Upon choosing the number of physicians in the tool, the number with burnout is calculated by type (primary care, surgical specialties, other specialties), using the prevalence estimates provided by Han et al.,[8] averaged across age groups (< 55 years, ≥ 55 years). The number of registered nurses with burnout is then estimated by applying the prevalence figure from Cimiotti et al.[9] to the number of nurses entered into the tool. The latter is calculated by applying the U.S. nurse-to-physician ratio of 4.3[27] to the number of physicians.

The cost associated with physician turnover is estimated, according to physician type, by applying the estimated cost of losing/replacing a physician,[8] to the number of physicians who leave their position as a result of burnout. The latter is calculated by multiplying the estimated number of physicians with burnout who leave their position by the probability that the leaving is the result of burnout.[8] The same process is used to calculate the cost associated with nurse turnover. However, we were unable to find nurse-specific inputs for the proportion with burnout who quit, or the probability that the move was the result of burnout; thus, physician-specific estimates for these inputs are used alongside nurse-specific estimates of burnout and cost of replacement.[9,10] The percentage of nurses with burnout who leave their position is estimated by calculating the average

across all physician types.

The number of physicians who reduce work effort, according to physician type, is calculated by applying the conditional probability of reducing effort given intent, and the probability that burnout results in an intention to reduce work effort, to the estimated number of physicians with burnout, all provided by Han et al.[8] Due to a lack of comparable inputs for nurses, physician figures are applied to the estimated number of nurses with burnout. Both the estimated percentage of nurses with burnout who intend to reduce their work effort, and the reduction in clinical hours associated with burnout, are estimated by calculating the average across all physician types.

The cost of lost physician work time due to liability claims is also estimated according to physician type. The probability that burnout results in a malpractice suit[15] is applied to the number of physicians with burnout, by type, which is then multiplied by the relevant cost of lost work time per claim,[16] according to whether or not the claim resulted in payment.[17] Given that physicians lose work time with each liability claim, regardless of whether it is paid out, the lower end of the lost-time range provided by Mello et al.[16] is applied to claims that do not result in payment, while the upper end of the range is applied to those that do. The average cost of each paid claim is estimated according to indemnity payments, administrative expenses, and defensive medicine costs.[16] The cost incurred by the hospital for medical errors associated with burnout is estimated by applying the probability of burnout resulting in a perceived medical error,[18] to the number of physicians with burnout, and multiplying by the estimated median, direct cost of a medical error to the hospital.[19]

The final component of the tool pertains to the potential cost offsets associated with reduced lengths of stay for gallbladder surgery, depression, and bipolar admissions, via the implementation of a biophilic intervention. First, the numbers of general surgeons and psychiatrists at the facility are estimated by applying the nationally representative proportions of all surgical and other specialists who were general surgeons and psychiatrists, respectively, and were involved in patient care, to the respective number of surgical and other specialists entered into the calculator.[24] The numbers of general surgeons and psychiatrists are then multiplied by the estimated annual number of gall bladder surgeries performed by a general surgeon and depression and bipolar admissions initiated by a psychiatrist, respectively. Finally, the annual number of each admission type is multiplied by the expected reduction in length of stay via biophilic intervention for each admission type, and by the national average cost of a hospital inpatient stay.[26]

Strengths and Limitations

The budget impact tool presented here is the first designed to estimate both the annual costs incurred by hospitals as a result of provider burnout, and the cost offsets that could be realized by incorporating biophilia into their architectural design.

As with any model of this sort, the primary limitation pertains to the assumptions made when choosing/applying inputs. That is, despite our comprehensive review of the biophilia literature in health care settings, the scarcity of empirical data sufficient to serve as model inputs, necessitates certain assumptions. For example, in some instances, a particular input may have been available only for physicians, in which case the assumption was made that it would be roughly equivalent for nurses. Similarly, due to the lack of an estimated marginal effect of a change in EE on the likelihood of a malpractice suit, we relied on the estimate for the effect of a change in EE on the likelihood of a medical error. Moreover, despite our best efforts to ensure only high-quality estimates are used as model inputs, quality does vary across publications.

Additional limitations pertaining to inputs, include our inability to: a) incorporate all provider types into the calculator, due to a lack of sufficient, existing literature; and b) control for provider characteristics (e.g., age, gender, years of experience) for certain inputs, such as burnout prevalence.

Although the tool estimates cost from the hospital perspective, not all cost inputs may accurately reflect those incurred by the hospital. For example, the estimates for indemnity payments, administrative expenses, and defensive medicine costs are calculated from a national, medical liability system perspective. Therefore, although the hospital will incur many of these costs, either directly or indirectly through insurance premiums, the cost categories may include resources that are not directly relevant. Furthermore, because of the manner in which liability costs are incurred, the timing with which the proposed cost offsets would occur may not be accurate, particularly for year 1. For example, even after reducing burnout and the associated risk of liability, it may take some time for defensive medicine costs to diminish, or for hospitals to see a decrease in their insurance costs.

Regarding the extent to which the intervention is effective at reducing burnout, as discussed previously, numerous studies have observed benefits associated with biophilia in health care settings, but only one did so in a manner that allowed for an estimated marginal effect on an objective measure of provider burnout (i.e., EE),[20] thereby allowing extrapolation of the findings to studies that estimated/reported the marginal effect that a change in EE has on the outcomes examined in this study.

Finally, the tool assumes: a) that the rates at which burnout-related costs are incurred and benefits (i.e., cost offsets) accrue, would remain constant over time; and b) that the real (i.e., inflation-adjusted) cost of maintaining the intervention does not rise faster than the costs associated with the affected resources. Given that medical inflation typically outpaces inflation in the rest of the economy—e.g., average annual medical inflation rate (2000-2020) = 3.5%, vs. 2.0% for all non-medical goods and services–in reality the benefit to the hospital would likely increase over time.

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