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Mission of the *Academy Journal*

As the official journal of the AIA Academy of Architecture for Health (AAH), this publication explores subjects of interest to AAH members and others involved in the fields of health care architecture, planning, design, and construction. The goal is to promote awareness, educational exchange, and advancement of the overall project delivery process, building products, and medical progress that affect all involved in those fields.

About AAH

AAH is one of 21 member communities of The American Institute of Architects (AIA). AAH is unique in the depth of its collaboration with professionals from all sectors of the health care community, including physicians, nurses, hospital administrators, facility planners, engineers, managers, health care educators, industry and government representatives, product manufacturers, health care contractors, specialty subcontractors, allied design professionals, and health care consultants.

AAH currently consists of approximately 7,000 members. Its mission is to provide knowledge which supports the design of healthy environments by creating education and networking opportunities for members of – and those touched by – the healthcare architectural profession.

Please visit our website at aia.org/aah for more about our activities. Please direct any inquiries to aah@aia.org.

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About the journal

As we start the 23rd year of the Academy Journal, published by the AAH Knowledge Community, this edition includes articles that support the enhancement of the built environment for health care.
As the official publication of the Academy, the Journal publishes articles of particular interest to AIA members and the public involved in the fields of health care architecture, planning, design, research, and construction. The goal has always been to expand and promote awareness, educational exchange, and advancement of the overall project delivery process, building products, and medical progress that affects all involved in those fields.

Articles are submitted to, and reviewed by, an experienced, nationally diverse editorial review committee (ERC) of medical and architectural professionals. Over the years, the committee has reviewed hundreds of submissions, responded to writers' inquiries, and encouraged and assisted writers in achieving publication. In its over 20-year history, the Journal has provided valuable opportunities for new and seasoned authors from the architecture and health care professions, including architects, physicians, nurses, other health care providers, academics, research scientists, and students from the US and foreign countries.

Published articles have explored a broad range of medical topics, including research trends, the future of health care architecture, cardiac care, future and evolving technology, patient rooms and patient safety, lighting design for health care, psychology, workplace design, cancer care environments, emergency care, women's and children's care, and various health care project delivery methods.

We encourage graduates who have received health care research scholarships and others involved with research within the health care architecture field to submit their research to the Journal for publication consideration. We will continue to develop a cross-referenced article index and a broader base of writers and readers. The deadline for the 2021 call for papers is May 27, 2021.

Since the late 1990s, this free publication has expanded to include worldwide distribution. And we are proud to report that as our readership continues to grow, it also expands internationally. Readers have viewed the Journal online from the US, Canada, Europe, the Caribbean, Asia, Africa, India, and Saudi Arabia, just to name a few. The Journal is available to the 94,000 AIA members and the public on the AIA website at aia.org/aah.

Special thanks to AIA for its continued support and hard-working staff and to the many volunteers who have contributed to our growing and continued success including Doug Paul and Southern Ellis for their leadership on behalf of the AIA and AAH. I would especially like to thank the other members of the 2020 ERC: Donald L. Myers, AIA, NCARB; Angela Mazzi, AIA, ACHA, EDAC; Sharon Woodworth, FAIA, FACHA; Dale A. Anderson, AIA, NCARB, LEED AP BD+C, CSBA, EDAC, MBA, GGP, ACHA; and Erin Mcnamara, EDAC. As always, we appreciate your feedback, comments and suggestions by emailing aah@aia.org.

Letter from the editor

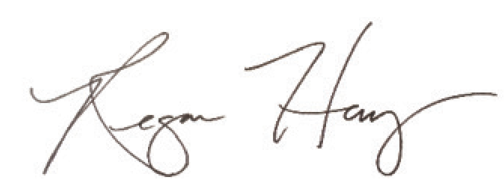
2020 has been a difficult year.

The COVID-19 global pandemic has impacted our lives in a profound way. Collectively, people have gained a new appreciation for the power of a virus and its potential impact to our hospitals, economy, and social networks. Our friends and colleagues in healthcare have been tested in a manner that will have meaningful consequences on the industry and what it means to dedicate one's life to care for another. Many of us have waited on news from scientists, cheered for progress, and followed FDA trials with great anticipation and awareness for the enormity of the pursuit. Never have I felt so appreciative of the people, networks, supply chains, and infrastructure that support our healthcare system.

As this journal goes to print, the dealth toll, in the United States, for COVID-19 stands around 300,000 and the first vials of vaccine are being administered to people on the frontline. There is great hope that we are at the beginning of the end of this saga, but still reeling from the exposed vulnerabilities to both the healthcare industry and society at large. We have learned so much and yet there is so much left to understand about the last ten months.

I look to 2021 and the years to follow as an opportunity to both celebrate our successes and learn from our missteps so that we are better and more prepared for future generations of frontline workers, patients in need, and vital equipment suppliers. There is great promise at the juncture between healthcare, design, and research. I applaud Orlando Maione for his vision to foster this journal and thank him for his many years of leadership and service as The Academy Journal Editor. We close out this year with an appreciation for the work accomplished and excitement for what is to come. I look forward to exploring with and learning from you in the years to come.

Cheers to a happy new year.



Regan Henry, RA, PhD, LEED AP, LSSBB
Editor, *Academy Journal*

Telehealth and the changing shape of health spaces

Sean Cottengim/GBBN Architects

INTRODUCTION

The quarantine of early 2020 is accelerating changes taking place within the American health care system. With stay-at-home orders and limits on elective and nonurgent surgeries forcing a much wider-spread adoption of telehealth practices, now is the time to ask how the rise of telehealth will impact the spaces in which we seek health services. And in considering this question, we need to think beyond the clinic. Of course, telehealth will change the demands that we put on clinical spaces, but they will also see us seeking health services in spaces—spaces we live and work in—that we generally understand to be separate from health care spaces.

This article will outline how telehealth specifically demonstrates a basis for speculating about possible futures and exploring the kinds of experiences we should expect to design in our built environments. More specifically, this article intends to illuminate the possible effect of existing and developing technologies on how and where health care is delivered, not to prescribe specific design solutions. Designers are responsible for imagining the impact of such developments for the purposes of updating their processes for the benefit of the client and society; this article seeks to prepare the ground for future design work

What is telehealth?

Telehealth can be defined several ways, but importantly it allows people to connect with a physician or other care provider using telecommunication devices that are common—eliminating the need to attend an in-office visit. There have been distinctions made between telehealth and telemedicine, but for our purposes the distinction is not important. Using the World Health Organization's list of "Elements germane to telemedicine," we can better understand the broad scope of what telehealth is:

- Its purpose is to provide clinical support.
- It is intended to overcome geographical barriers, connecting users who are not in the same physical location.
- It involves the use of various types of information and communication technologies (ICT).
- Its goal is to improve health outcomes (World Health Organization, 2010).

Telehealth refers to a broad range of health services, from simple phone access to health education or sending messages to your doctor to more sophisticated practices like a face-to-face conversation with your physician via a mobile device, which might also involve remote diagnostics monitoring. Some of these options are already integrated into digital platforms that house a patient's electronic health records, though the adaption of this kind of technology is uneven. It is worth noting that telecommunication technology changing access to and delivery of health care has existed, rhetorically, since 1876 when Alexander Graham Bell patented the telephone and, more realistically, as far back as 1924 when Radio News magazine depicted a "radio doctor" on its cover (Field, 1996).

Changes in the occurrence of telehealth

Several leading health systems have shown a significant increase in telehealth appointments. Many indicators have shown an exponential growth of telehealth during the quarantine.

While only 24% of organizations had an existing virtual care program by January 2020, reports indicate that telehealth visits will likely reach 1 billion by the end of the year (Forrester, 2020). The repercussions of this kind of growth will be with us for years.

Cleveland Clinic logged more than 60,000 virtual visits in March. That's a 1,700% increase from the previous month. And one study found that more than two-thirds of respondents said the pandemic has increased their willingness to try virtual care (Siwicki, 2020).
At the end of March, Stanford Medicine reported incredible growth of virtual health. "At 3,000 per day, televisits now make up 40% of all clinical visits at Stanford Health Care, 50 times higher than prior months. The all-time daily televisit high for Stanford Children's Health, before COVID-19 hit California, was 35; recently, clinicians conducted 500 in one day" (Stanford Medicine, 2020).

Willingness to adopt telehealth as a valid form of interaction is up as well. Even prior to the events of the COVID-19 pandemic, the Telehealth Index Consumer Survey reports that 66% of Americans were willing to use telehealth. And even seniors are on board, not just tech-savvy millennials (Amwell, 2019). It seems likely that comfort with—and patient willingness to adopt—telehealth will only grow as more and more people gain experience with it.

What might the research suggest?

The possibilities for telehealth and its technological successors to provide new ways to make connections between provider and patient raises new questions about the future landscape of health spaces. It is worth categorizing these types of interactions to organize our thinking on the types of spaces we may begin to include as "health" spaces.

For my purposes, I can set aside the finer points of what constitutes telehealth vs. telemedicine. What's important is the broader context of how telehealth provides care—or, even more broadly, how can people interact? It is not by coincidence that these types of interactions are not specific to medical care. This technology has been adopted rather quickly by communication and entertainment industries. Your nephew has probably been having digital interactions with his friends through his gaming console for years now. It is the medical sector, however, (and the organizations that provide that care) that is currently acknowledging these possible modes of interaction and dealing with rules and regulations built for a system that simply did not accommodate these technologies. A simple categorization of types of interaction illuminates the spectrum of possibilities for the near and far future.

Synchronous physical interaction—Actual attendee and actual attendee
Two or more people have a physical interaction in a physical place; the physicality of place is pertinent to the interaction. This could be a typical office visit, a surgery, a specialty scan, one-on-one or group therapy in an actual space. Basically, it is any conventional medical visit one would be used to. Social interaction typically works best in this way, as well as the efficient transfer of physical goods or services (chiropractor) or where the specialty resources needed have limited mobility or it's not feasible to provide them in a mobile capacity.

SYNCHRONOUS:

Direct interaction, happening simultaneously. A phone call is an example.

ASYNCHRONOUS:

Interaction that happens over a staggered period of time. Email is an example.

PHYSICAL:

Happening without the aid of telecommunication technology. An in-person conversation is an example.

DIGITAL:

Happening with the aid of telecommunication technology, and in the absence of a physical interaction. A voicemail is an example.

Ref 1. Helpful terminology

Synchronous digital interaction—Actual attendee and digital attendee
Two or more people are interacting digitally, but only one physical space is pertinent to the situation.

The virtual house call
The most common current occurrence of a telehealth visit—virtual, "face-to-face" interaction between the provider and the patient in real time—allows for a decrease in waiting time and costs; thus, it is more convenient in most cases.

The disaster dog
AI or digital interaction such as disaster relief or drone-operated assistance or rescue. A practitioner's expertise is needed in a situation, but it's too risky for them to be there in person. Think the Boston Dynamics robot dog with facetime running on a tablet on its head.

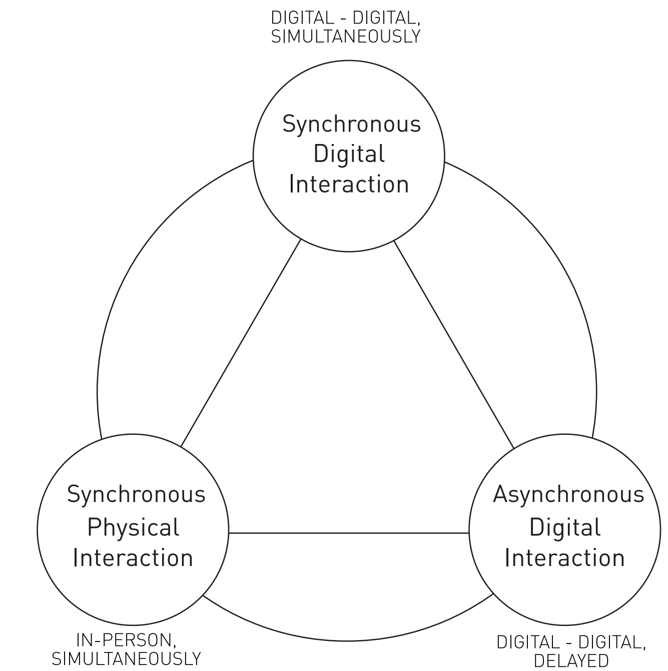
The robot buddy
In-home care and monitoring provided by a virtual or an AI assistant. Think Baymax from Big Hero Six (or simply think health care robot).

The third place—The masseuse, barbershop, gym
People use these services or interact in these places due to physical aspects of the body. While the primary impetus for using these services is not built around the remote presence of a health care worker, digital technology makes it easy to imagine these spaces being integrated into a broader health care ecosystem. Integration of wellness care at these locations would not only remove barriers for participation in individual health, but could also increase proactive, preventative care by catching issues before they become a problem "worth going to the doctor" for.

Asynchronous digital interaction—Digital attendee and digital attendee
Two or more people meet virtually where their location, appearance, or timing is not important.

While patient-provider interaction is between two parties, it need not be face-to-face or even within the same space over a period of time (think of passing messages back and forth over mobile devices). For that matter, there may be certain therapies provided that are enhanced by using an avatar or otherwise making one's identity anonymous. An important aspect of this interaction type, however, is the privacy of where the user is accessing the interaction. Think about answering sensitive questions over the phone for example—there may be a level of digital or physical privacy necessary (but this could occur with headphones or perhaps a small private area to text or call).

Telehealth has the power to be integrated into people's daily lives in creative and transformative ways. It may be obvious that a video call with a doctor is convenient, but the transformative power of care being literally disconnected from the clinic space can remove many of the barriers associated with an individual not pursuing



Ref 2. The spectrum of interactions

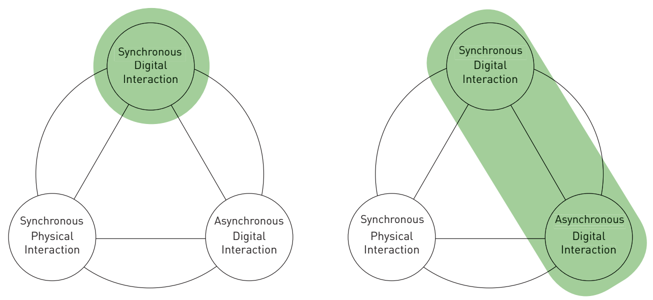
care. Receiving care for mental health, sexual health, or other health concerns may invoke deterrent social stigmas against receiving that care. When care is provided with anonymity, convenience, and incentives a community can benefit from avoiding these deterrents (Knaak, Mantler, & Szeto, 2017).

Implications for practice

What is the point of framing telehealth in this way?

Health organizations, both in their present, familiar form as well as possible future forms, will continue to shape the physical environment just as they do today. It is part of a designer's job to be comfortable considering these possibilities and what opportunities they hold.

In all the cases outlined there are characteristics of space that are important. For synchronous digital interactions we should be considering the privacy and comfort of the user side—will people begin to have a specialty space in their home for digital interactions? What if a user is going to a specialty physical space, but the provider is attending digitally? What questions does that raise about sequence of space, experience, comfort, privacy, and safety? Providing health care in the future can take several appearances, but the spectrum of synchronous/asynchronous, digital/physical may take different forms for different purposes or communities. Both designers and health providers should be anticipating future scenarios, either within the existing health system or one drastically reshaped by market disruptors, in order to reimagine the kinds of spaces that will link individuals and communities to receiving care.



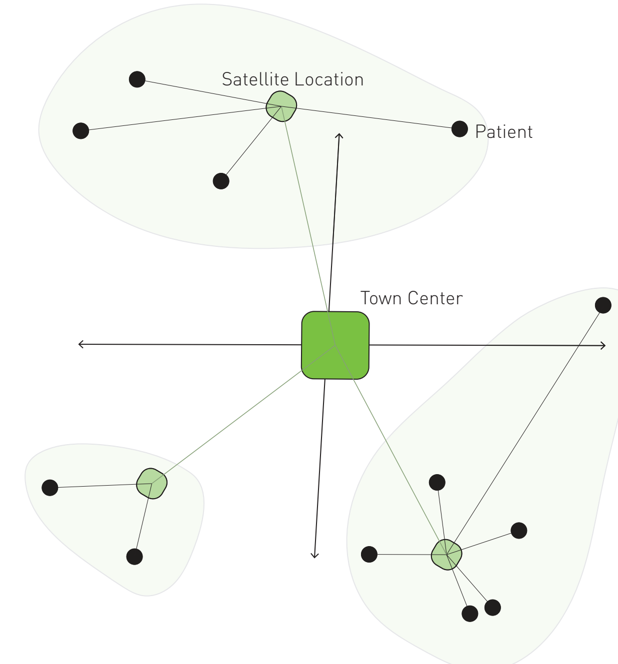
Ref 3. Health care providers can engage in one or several of these models of interaction. Are you going to choose one, two, or all of these?

Possible future scenario #1—Rural

There are indications that health care in rural environments is suffering. For instance, one study found that nearly half of hospitals remaining in rural areas are operating in the red, and rural residents are less able to access and afford care (Advisory Board, 2020). Telehealth is already being considered as a possible response to this problem. For this scenario we will follow a clinician in a rural county in middle America in the near future. This municipality has provided its population with in-home diagnostic kits (such as the Tyto home care kit) as well as public access to internet services to bolster the population's access to telehealth services. Much of the typical wellness and preventative care in this community comes from synchronous digital interactions with physicians who do not live in the immediate area—a virtual house call. The doctor(s) telehealth services could be supported by a clinician who works in a physical satellite location between the town center and the surrounding residents. This model provides space for the clinician, medical equipment, and limited medication in strategic locations near parts of the population. This position is one of a few that facilitates many of the synchronous physical interactions necessary in the community and provides efficient emergency response to a portion of the community. She is a certified dialysis and PET scan technician as well as a dietician. She works with remote physicians and experts and provides them access to information they need to diagnose members of the community. Her physical location provides for care that is a step up from virtual house calls.

A typical visit to the satellite location might look like this. A member of the community comes to the satellite location after receiving a directive from her doctor to get a PET scan to further diagnose signs of heart disease. At the location she is met by our clinician who operates the machinery and facilitates the digital oversight with the remote doctor (synchronous digital and physical interactions). While the doctor analyzes the results remotely, the clinician meets with the patient to discuss potential dietary changes associated with successful recovery from heart issues. She then directs the patient to a central facility, which has a grocery store located in the middle of town. When the patient arrives, our clinician then walks her through recommendations (synchronous digital interaction) for grocery purchases. While the patient waits on further results from the doctor, she spends the remainder of the afternoon in the community center portion of the wellness center, which includes a public library and a test kitchen where the patient can learn to cook new recipes and engage in other social interactions (synchronous physical interaction) that contribute to both her overall wellness as well as increase her chances of sticking with a new wellness regimen specified by the doctor. As the results come back, the physician requests that the patient attend yoga classes a few days a week, which are also offered at the wellness community center, to ensure she is getting the exercise she needs.

This version of a health care future treats the general access to health services as a sequence of experiences that transform from completely remote/digital/in-home as the first interaction toward centralized, community-based access to more specialized or physically dependent aspects of wellness. Instead of a single hospital campus that houses all functions, it's a dispersed model. Most provider-patient interaction is at the outskirts and in the home, and much more of the community interaction and lifestyle wellness options is centrally located. Instead of one local doctor who does in-home visits, there's a panel of doctors from around the world providing digital interactions and directions to smaller staff of certified technicians who can assist in running specialized services.



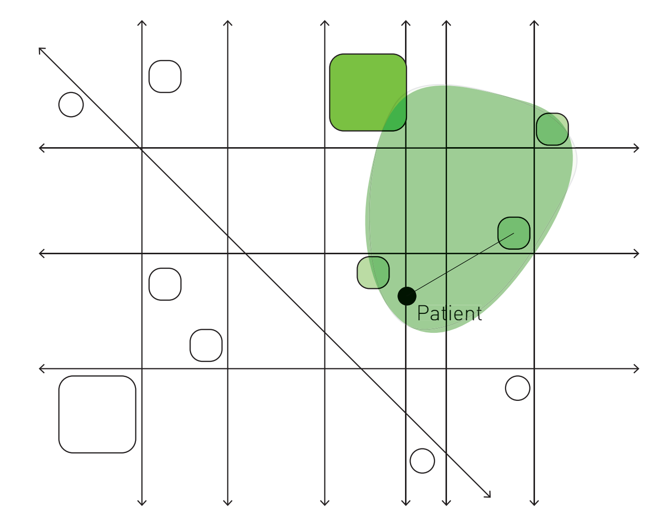
Ref 4. The network of care: In-home virtual care to satellite specialties, to centralized community and emergency services.

Possible future scenario #2—Urban

This scenario imagines how similar kinds of access could be employed differently in an urban environment, making adoption of such strategies more likely for a health system to employ in all geographic areas (Huilgol, Joshi, Carr, & Hollander, 2017). As environmental concerns advocate for renovation rather than new construction, and the introduction of autonomous vehicles allow for a reuse of parking spaces (Shaver, 2019), there is the opportunity to create a diverse set of health spaces in an existing urban context.

We follow a resident of a medium-large city who is out of his house for a visit to the nail salon. While there, the pedicurist notices one foot is slightly swollen and blue and tells the long-time customer (synchronous physical interaction). He is told that this could be a sign of circulation problems, and possibly even more severe medical issues, and the pedicurist asks if they have permission to connect him with a specialist who can provide medical advice—they can do it digitally in a private space near the back of the salon. Within minutes a physician has seen the patient's foot and has recommended he get an MRI done within a day or two as his symptoms can be a sign of deep vein thrombosis (synchronous digital interaction). The patient takes the doctor's order and uses his mobile device to search for available MRI spaces within a few city blocks. His mobile app prompts him to a few spaces within walking distance (think of it like finding an ATM through your banking app) over the next three hours, and he reserves a space. Because the spaces are dispersed, and their operation remote, this allows for more efficient scheduling and a larger volume of appointments. After consulting his calendar, the patient receives a notice from his health provider for grocery coupons at two local stores as well as a calendar of exercise classes at an independent bootcamp gym that is partnered with his health provider (asynchronous digital interaction). The patient accesses the diagnostic space using a digital code (a bit like going to an Amazon drop-off location) and enters the room. Once within, a synchronous digital interaction begins between the patient and a technician who conducts the test (Imaging Technology News, 2006). It takes only a short time, and the patient exits while the space sanitizes itself. An hour later the patient receives notice that he needs direct observation, and he can be immediately checked in at one of two hospitals in the area. A car will be on its way soon to escort him for further medical observation.

This model exploits the potential of telehealth to align supply and demand, matching provider and patient at almost any time or place throughout the city (and beyond). It also provides choice and flexibility for how the patient may encounter that care.



Ref 5. Flexible options activated by patient choice, availability, and convenience. As individuals move through the environment, schedules, space availability, patient and provider availability, and preferential factors are synched to locate the exact time and space for the delivery of care.

Wrap it up—It's all about people, people

Ultimately what is emerging from this is a variety of ways to connect to people, a spectrum of choice. Each system, each community, need not necessarily do all things at all times—in fact, that is likely too difficult to manage. The health systems of the future will be integrated and coordinated and likely allow people to curate their care much like they curate their other lifestyle preferences. This will generate spaces that permit new and flexible ways for people to connect—be that the centralized community center or the completely anonymous virtual visit.

If we can learn something about each type of "space" that care is tethered to, we may be able to provide better use of space, better services within the space, and better spaces where care is not currently provided. Imagine using a park to complete virtual therapy without sacrificing privacy. Imagine the difference between going to a clinic versus going to a produce market and receiving consultation about diet or even therapy for social anxiety.

These virtual and physical interactions can take cues from one another and begin to blend rather than be binary options. Can there be multiple types of options for people to pursue? Just like spaces designed for choice, prospect, and refuge, health care systems and their spaces can be designed to support a multitude of point-of-care options.

Perhaps this spectrum of interaction is best dealt with as a set of possibilities a health organization will need to contend with. There is no right or wrong path forward. Nor is any one possibility a definite outcome. Many of these forms of interaction are already present and will need to be considered in the future model of health delivery. This is the most valuable way to digest a speculation—to take it as a narrative possibility and consider the effects of that kind of future. Perhaps this spectrum is helpful in creating models that are different and appropriate for meeting different needs in different communities. Exploring possibilities through a narrative framework is a rich and valuable mental exercise for designers and clients alike. It allows us to take trends and ideas that exist and say, "If the future looked like this, what might I do now to chart my path forward?"

Call to action: Questions we need to address now

This exploration of the possible futures that are beginning to take shape through the influence of remote care technology raises more questions than it answers. However, recent changes to Medicare reimbursement for telehealth care via executive order, and a subsequent proposal from Congress to make those changes permanent, indicate a willingness in the US to pursue a path toward making telehealth a viable endeavor for practitioners (Sokol, 2020). Among other questions that we'll need to address are: Is the management and logistics of these kind of dispersed care models all going to be run by a hospital or will they enlist independent partners? Should it be run by a hospital? How will the dynamic change between physicians and administrations? How will you handle multiple maturation lines? How do you evolve individuals or communities who have traditional views of medical access? As more of health care interactions become encoded in digital technology, who will own all the medical data? To ask these questions both internally as designers and with communities and clients is essential to the design process.

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Tailored lighting intervention to promote entrainment in myeloma transplant patients—A field study

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ABSTRACT

Light is the major synchronizer of circadian rhythms to the local position on Earth. Exposure to light at night and insufficient exposure to light early in the day has been linked with poor sleep and a host of health and behavioral problems. Myeloma patients spend two to three weeks inside their hospital rooms during transplantation, which can lead to circadian disruption due to low light levels typically found indoors. We performed a pilot study to determine whether circadian-effective light could promote entrainment in myeloma patients. We hypothesized that an increase in circadian entrainment would lead to reduced cancer-related fatigue, depression, and sleep problems. Fifty-five participants were randomly assigned to two lighting interventions that used freestanding luminaires to deliver either circadian-effective light (n=27) or circadian-ineffective light (n=28) throughout the hospital room between 7am and 10am during every day of hospitalization. Results showed an increase in nocturnal melatonin levels and an improvement in sleep in those receiving the circadian-effective (active) intervention. The present results suggest that light can be used to help myeloma transplant patients maintain circadian entrainment while hospitalized. Design guidelines and implementation tips to increase circadian stimulus in hospital rooms are also discussed.

Introduction to circadian rhythms

The 24-hour pattern of light and dark that accompanies Earth's axial rotation regulates the physiology and behavior of almost every living thing on the planet. For humans, light reaching the retinas is the primary exogenous (external) cue that synchronizes or entrains the body's endogenous (internal) master biological clock and thus our circadian rhythms to the solar day, essentially telling our bodies to do the right thing at the right time. Other secondary exogenous cues include social activity (Salgado-Delgado, Tapia Osorio, Saderi, & Escobar, 2011), meal times (Wehrens et al., 2017), and physical activity (Moreno et al., 2019), among others. Sleeping and waking, feeding and fasting, the regulation of core body temperature, blood pressure, and the secretion of hormones are just a few examples of circadian rhythms. The term "circadian," coined by biologist Franz Halberg (1959), is a blended word derived from the Latin circa ("about") and dies ("day").

Because the human circadian system free-runs at an average period of about 24.2 hours—slightly longer than the solar day—a daily cue of light and dark is required to advance the circadian system by about 10–15 minutes, thereby continually resetting the master biological clock to maintain circadian entrainment (Czeisler et al., 1981).

But what light gives, light can also take away. Exposure to light at the wrong time, or not receiving enough light at the right time, has become increasingly common since the advent of electric lighting over a century ago. Exposure to light at night, and even a complete reversal of the day-night pattern in the case of night-shift workers, are now facts of life in our 24-hour society. But exposure to light at night and insufficient exposure to light early in the day has been linked with poor sleep and a host of health and behavioral problems. Long-term disruption of the daily cycle of light and dark can lead to chronic disruption of the circadian system, which has been associated with metabolic dysregulation (leading to weight gain, obesity, and type 2 diabetes) (Depner, Stothard, & Wright, 2014), certain forms of cancer (Samuelsson, Bovbjerg, Roecklein, & Hall, 2018), depression (Germain & Kupfer, 2008), and other maladies (Abbott, Malkani, & Zee, 2018).

Lighting characteristics affecting the circadian clock

Four characteristics of light and light exposures play crucial roles in the circadian system's response.

1. The amount or level of light received at the eyes: "Is it bright or dim?"
   Early circadian research in animal (Sharma & Daan, 2002; Takahashi, DeCoursey, Bauman, & Menaker, 1984) and human (Boivin, Duffy, Kronauer, & Czeisler, 1994, 1996) models found that varying light levels at the eyes differentially affect the nighttime suppression of the hormone melatonin (the release of which prepares the body for sleep) and zeitgeber time, either advancing or delaying the timing of the

circadian system's 24-hour cycle. The greater the amount of light, the greater the melatonin suppression and the greater the advance/delay in zeitgeber time (A zeitgeber is an environmental synchronizing cue, like light, for example).

2. The spectral properties of the light experienced: "Is it warm (reddish) or cool (bluish)?" Because it has a peak spectral sensitivity that occurs around 460 nm (Brainard et al., 2001; Thapan, Arendt, & Skene, 2001), the human circadian system is maximally sensitive to short-wavelength ("bluish") light (e.g., 465–475 nm), which in turn is maximally effective for stimulating the circadian system. For the same photopic light level, a light source emitting greater short-wavelength light content will be more effective for activating the master biological clock than a light source emitting more long-wavelength ("reddish") light. Because light of all wavelengths evokes an alerting response at any time of day or night, long-wavelength light is especially useful for promoting alertness during the afternoon and evening without disrupting the circadian system (Figueiro, Bierman, Plitnick, & Rea, 2009; Plitnick, Figueiro, Wood, & Rea, 2010).

3. The timing and duration of light exposures: "When, and for how long, was I exposed to light?" Humans are more sensitive to light stimulus during the evening hours, at night, and in the early morning compared to the middle of the day (Figueiro, 2017; Jewett et al., 1997). Experiencing high levels of light later in the day and in the evening will delay the timing of the master biological clock, causing us to fall asleep later than our usual bedtime and leading us to sleep in or feel tired on waking the next day. Conversely, experiencing high levels of short-wavelength light early in the morning will advance the timing of the master biological clock, causing us to fall asleep earlier and wake up earlier the next day. Morning light will also reset the master biological clock, helping to entrain our circadian system to the solar day. Again, because the circadian system free-runs at a period that is generally longer than the 24-hour solar day, we need light early in the day to maintain regular bedtimes. Longer exposure durations are also more effective at suppressing melatonin (Nagare, Rea, Plitnick, & Figueiro, 2019).

4. A person's history of light exposures: "How much light have I received over the past 24 hours?" While it is well accepted that exposure to higher light levels results in greater melatonin suppression at night, research also shows that a one-day light exposure of 200 lux suppresses melatonin to a greater degree when it is preceded by three days of dim light (< 1 lux) compared to three days of the same 200-lux source (Smith, Schoen, & Czeisler, 2004). While the visual system's response to light is virtually instantaneous, the circadian system's response to light is cumulative (Figueiro, Nagare, & Price, 2018).

When appropriately specified according to these four characteristics, light exposures can be tailored to remedy symptoms of seasonal affective disorder (Golden et al., 2005), increase sleep efficiency in older adults (including those with Alzheimer's disease) (Fetveit, Skjerve, & Bjorvatn, 2003; Figueiro et al., 2014; Van Someren, Kessler, Mirmiran, & Swaab, 1997); promote circadian rhythmicity in premature infants (Rivkees, 2003); increase alertness at all times of day and night (Badia, Myers, Boecker, Culpepper, & Harsh, 1991; Cajochen et al., 2005; Cajochen, Zeitzer, Czeisler, & Dijk, 2000); and improve alertness and selected measures of performance (Sahin & Figueiro, 2013; Sahin, Wood, Plitnick, & Figueiro, 2014).

Light and myeloma transplant patients

Multiple myeloma (MM) patients undergoing autologous stem cell transplantation (ASCT) experience clinically significant negative sequelae that affect prognosis and survival as well as quality of life. These sequelae include increases in production of inflammatory cytokines, higher rates of neutropenic fever, and higher symptom burden (e.g., depression, pain). These symptoms are associated with circadian rhythm disruption (CRD), a disruption in naturally occurring 24-hour cycles of hormone secretion, temperature, and rest-activity. CRD increases production of pro-inflammatory cytokines, causing a cascade of negative side effects, including higher symptom burden and increased risk of neutropenic fever. CRD has been associated with decreased prognosis and survival.

To address these concerns, we performed a pilot research study to determine whether circadian-effective light could promote entrainment (as measured by an increase in nighttime melatonin levels) in MM patients. For the purpose of this contribution, we limited our focus on the range of negative sequelae experienced by patients undergoing ASCT, and we hypothesized that an increase in circadian entrainment would lead to reductions in cancer-related fatigue, depression, and sleep problems among MM patients, both during and after ASCT hospitalization.

Methods and materials

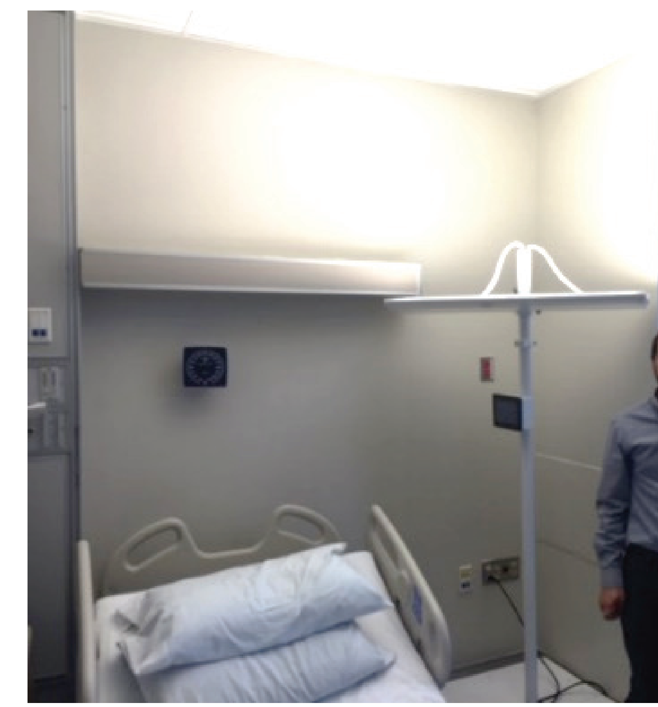
Tailored lighting intervention

Fifty-five participants were randomly assigned to two lighting interventions delivering either circadian-effective light (n=27) or circadian-ineffective light (n=28) throughout the participants' rooms from 7–10am daily during hospitalization. The circadian-effective light stimulus was specified following the Rea et al. model (Rea, Figueiro, Bullough, & Bierman, 2005). Following the model, the measured spectral irradiance at the cornea is first converted into circadian light (CL_A), which reflects the spectral sensitivity of the circadian system. CL_A is then transformed into a circadian stimulus (CS) value, which reflects the absolute sensitivity of the circadian system. Thus, CS is a measure of the effectiveness of the retinal light for stimulating the human circadian system, as measured by acute melatonin suppression, from threshold (CS = 0.1, or 10% melatonin suppression) to saturation (CS = 0.7, or 70% melatonin suppression). It is important to note that, strictly speaking, CL_A and CS characterize the spectral and absolute sensitivities of light-induced nocturnal melatonin suppression as regulated by the master biological clock. It is assumed, however, that CL_A and CS characterize the spectral and absolute sensitivities of the entire human circadian system because the biological clock plays a key role in regulating a wide variety of daily bodily functions, such as hormone production and sleep. For the purpose of the present study, it was assumed that the spectral and absolute sensitivities of nocturnal melatonin suppression are similar to those controlling light-induced changes of circadian timing and circadian entrainment.

Acuity Brands developed an experimental freestanding luminaire that used 3000 K, ambient "warm white" light to deliver either a CS of 0.3 for the circadian-effective ("active") bright white light (BWL) intervention (approximately 1000 lux at the participants' eye level) or a CS of 0.1 for the comparison ("inactive") dim white light (DWL) intervention (approximately < 50 lux at the participants' eye level). A warm light source was chosen for both interventions to make the space appear less institutional and more residential.

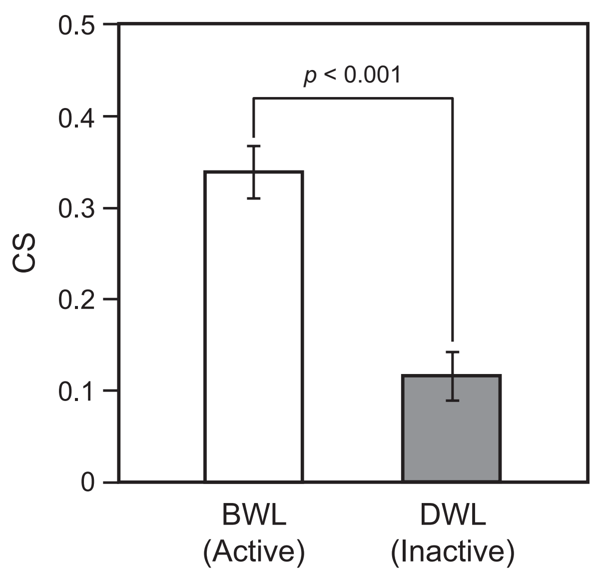
The interventions used ambient lighting to illuminate the entire room (Figure 1), rather than a light box, to reduce patient burden and promote compliance. The luminaires remained in the patients' hospital rooms for the duration of the study. They were pre-programmed to deliver the respective lighting interventions and turn on every morning from 7am to 10am. To ensure that the lighting intervention was successful, Daysimeters (Figueiro, Hamner, Bierman, & Rea, 2013), a type of light meter calibrated to measure CS, were placed behind the patient's bed and on the luminaire. The participants wore a third Daysimeter as a pendant during waking hours for their entire hospital stay. Figure 2 shows that, as hypothesized, those in the BWL intervention received significantly ($p < 0.001$) higher CS values than those in the DWL intervention.

FIGURE 1



The experimental luminaire used to deliver the BWL (active) and DWL (inactive) interventions in participants' rooms.

FIGURE 2



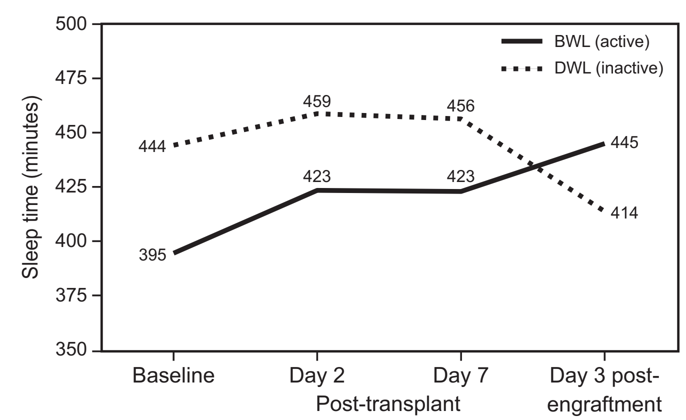
Mean CS values recorded by the bed Daysimeter when the lighting was programmed to be energized (7–10am). (The error bars represent standard deviation.)

Outcome measures
Outcome measures were assessed prior to hospitalization (baseline), on days 2 and 7 post-transplant, and on day 3 of engraftment (i.e., when the body accepts the transplanted stem cells). Day 3 of engraftment is usually the day before discharge from the hospital. We collected 24-hour actigraphy data to obtain objective measures of sleep; nighttime urine to obtain 6-sulfatoxymelatonin (6-SMT), a melatonin metabolite; and questionnaire data on participants' depression and cancer-related fatigue. Only those outcomes that yielded statistically significant (or nearly significant) results from the lighting interventions are reported below, thus excluding the participants' statistically nonsignificant subjective assessments of depression and cancer-related fatigue.

Results

Sleep
At baseline, the participants in the BWL (active) intervention reported shorter (but statistically nonsignificant) sleep time than those in the DWL (inactive) intervention. The sleep time of those in the BWL (active) intervention steadily lengthened over the course of the study, however, while the sleep time of participants in the DWL (inactive) intervention plateaued from days 2 through 7 and actually decreased by day 3 of engraftment compared to baseline. This was reflected in a nearly significant ($F_{4,120}$ = 2.31; p = 0.063) lighting intervention × assessment time (baseline vs. day 3 of engraftment) interaction for sleep time (Figure 3). Overall, sleep time decreased through time in participants who received the DWL (inactive) intervention, while it increased in those who received the BWL (active) intervention.

FIGURE 3



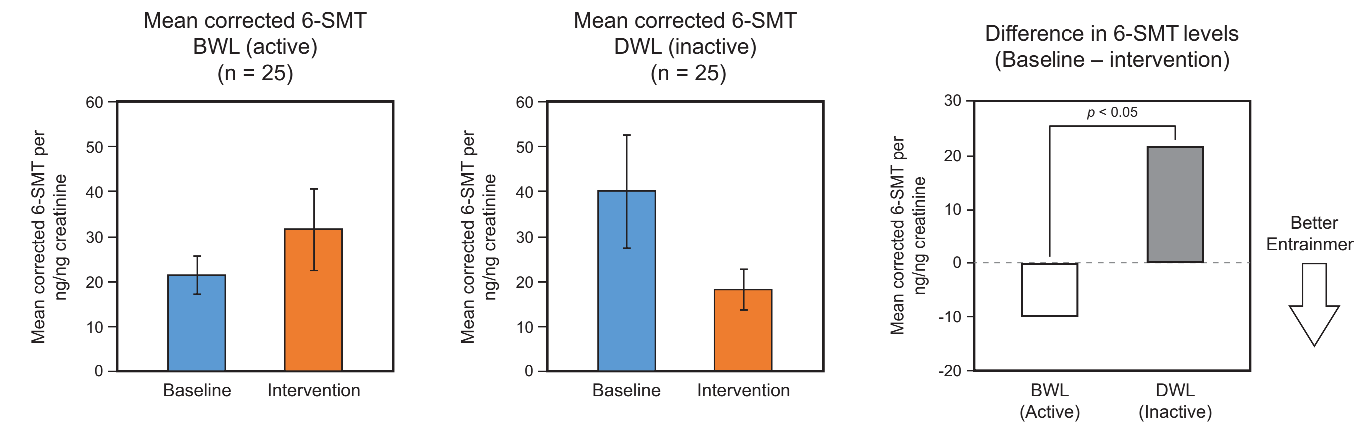
Sleep time in minutes at baseline (before hospitalization), day 2 after transplant, day 7 after transplant, and day 3 of engraftment (generally the day before discharge from the hospital). Sleep time decreased in those exposed to the DWL (inactive) intervention, while it increased in those exposed to the BWL (active) intervention.

Creatinine-corrected urinary melatonin-sulfate (6-sulfatoxymelatonin, 6-SMT)
There was a steep decline in 6-SMT levels for patients in the DWL (inactive) intervention, while 6-SMT levels for participants in the BWL (active) intervention were slightly higher, suggesting that the latter intervention maintained circadian entrainment during hospitalization. Due to the small sample size, the lighting intervention × assessment time interaction for 6-SMT levels approached significance ($F_{1,47}$ = 3.92; p = 0.054) but was not adequately powered to reach significance at the 0.05 level (Figure 4). The difference between baseline and intervention was significantly greater (p < 0.05) after exposure to the BWL (active) intervention than after exposure to the DWL (inactive) intervention.

Discussion

The results reported here suggest that implementing a robust light-dark pattern in hospital rooms can promote circadian entrainment and improve sleep in MM patients. Given that improved sleep has been linked to a series of health benefits, the active lighting intervention employed in this study could be an important first step in improving patient health, especially among patients who are hospitalized for extended stays, such as those receiving ASCT or those being treated for stroke or traumatic brain injury in rehabilitation units.

FIGURE 4



Mean-corrected 6-SMT levels, which increased in those receiving the BWL (active) intervention and decreased in those receiving the DWL (inactive) intervention. (The error bars represent standard deviation.)

Although it was not confirmed by the present study, providing ambient circadian-effective light in hospital rooms has been shown to reduce symptoms resulting from disruption of the circadian system that are commonly experienced by hospitalized and survivor cancer patients, including cancer-related fatigue (Ancoli-Israel et al., 2012; Johnson et al., 2018; Redd et al., 2014) and depression (Desautels, Savard, Ivers, Savard, & Caplette-Gingras, 2018; Sun et al., 2014). Previous studies have also shown that bright white light delivered by light box (Litebook) reduced cancer-related fatigue and improved sleep efficiency among cancer survivors following completion of their treatment and release from the hospital (Wu et al., 2018).

These results should be interpreted in the context of a few important study limitations. Perhaps most importantly, the study is preliminary and was conducted with a small sample size. In our preliminary data, we observed a marginally significant (p = 0.059) lighting intervention × assessment time interaction for melatonin. The effect size for this interaction is f^2 = 0.09, which is midway between a "small" and "moderate" effect size using the Cohen (1988) characterization. Moreover, since the results do not include post-hospitalization assessments, it is not yet known whether circadian-effective light delivered during hospitalization affects cancer treatment symptoms during the post-transplant period. Larger clinical trials measuring immune function biomarkers should be performed to extend these preliminary results.

While we are still learning about the benefits of lighting design for the circadian system, the present research and the work of others in the field clearly show that avoiding disturbance from light at night and creating a robust light-dark pattern can stimulate the circadian system, promote daytime alertness, and yield benefits for health and well-being. Despite the study's limitations, our findings nonetheless demonstrate that this easy-to-deliver, low-cost intervention improves sleep and circadian entrainment among MM bone marrow transplant patients during hospitalization.

Implementation tips

A patient's stay in the hospital can range from a day to a few months. No matter the duration, lighting in a patient's room can positively impact the patient's psychological and physiological recovery. In addition to providing good visibility, low glare, and good color rendering, lighting for patient rooms should be designed to promote circadian entrainment by delivering high CS during the day and low CS in the evening to increase patients' sleep times and improve their sleep quality.

Circadian-effective lighting for designers and manufacturers
Circadian-effective lighting to promote circadian entrainment requires designers to create a CS schedule that, at a minimum, delivers a pattern of bright light during the day and dim light in the evening. Although not necessarily required, the CS schedule can mimic the spectral properties and illuminance levels that are provided by the daily solar cycle. As indicated in the UL Design Guidelines (Underwriters Laboratories Inc., 2019), the circadian-effective lighting design process includes six essential steps:

Step 1: Establish a circadian-effective lighting design criterion (e.g., CS = 0.3).

Step 2: Select a luminaire type (e.g., direct/indirect).

Step 3: Select a light source (e.g., 3000 K LED).

Step 4: Perform photometrically realistic software (e.g., AGi32) calculations for the building space.

Step 5: Calculate CS from the vertical illuminance (measured at the eye) and the light source's spectral power distribution (SPD).

Step 6: Determine whether the lighting system meets the circadian-effective lighting design criterion; repeat steps 2–6 if necessary.

The space's occupants are the most important considerations in circadian-effective lighting design and the establishment of a design criterion CS for step 1. One important thing to consider is the occupants' ages. Age-related changes to the eye can render CS prescriptions for elementary school students inappropriate for office workers or seniors in eldercare environments. It is also very important to take into account where, when, and how the occupants use the space. Because hospital beds can be angled to position patients upright (viewing the wall and windows) or fully reclined (viewing the ceiling), room lighting should accommodate both patient orientations. It is thus very important that lighting systems can provide appropriate CS levels without glare of direct views of luminaires in both positions. When specifying CS for patient rooms, it is recommended that illuminance be measured at the patients' eyes while sitting up at a 45° tilt and while laying down looking straight up at the ceiling (Figure 5). Establishing these parameters helps designers determine appropriate CS exposures and the timing of their delivery.

FIGURE 5

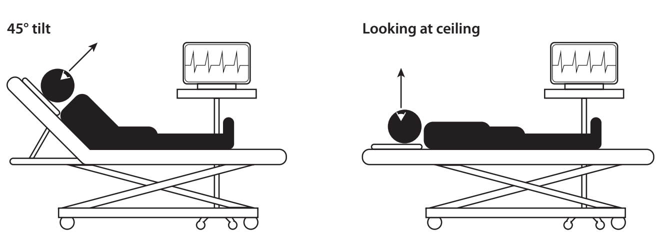


Figure 5: Light measurements in hospital rooms may need to be taken at 45° or 90° (horizontal) to account for patients' orientation(s) in bed.

As shown in Figure 6, several major lighting characteristics that are encompassed by design steps 2 and 3 contribute to how well the system can deliver the criterion CS:

- The light source's spectral power distribution (SPD), which represents the radiant power emitted by a light source as a function of wavelength, is crucial for circadian lighting design. Higher short-wavelength content generally delivers greater CS values for the same amount of photopic (lux) light at the eye.
- Vertical illuminance levels, or light at the occupants' eyes.
- The light source's intensity distribution, whether from a single luminaire or multiple luminaires, will determine how the light is distributed into the room and ultimately to the eye and work plane.
- Duration of exposure plays an important role in how the circadian system responds to a given light source. It should be noted that CS > 0.3 is based on a 1-hour exposure.

Once the fundamentals of occupant(s) and lighting characteristics are taken into account, the lighting design can be extended to incorporate information about the room to accomplish the aims of step 4. Lighting design software and manufacturers' published photometric data files (IES, or *.ies) are especially valuable tools for step 5, as they permit simulated predictions of luminaire performance, CS delivery, lighting power density (LPD), and energy usage.

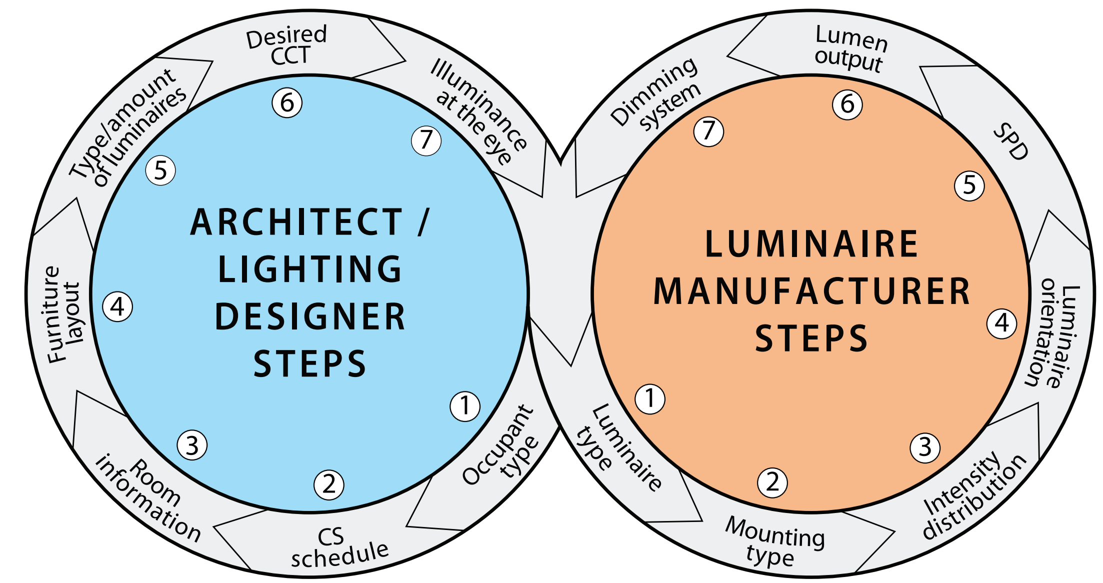
Finally, when you reach step 6, it is important to avoid viewing the design process as a hard-and-fast series of steps that inevitably lead to the desired outcome. Successful designs actually grow from a dynamic interchange between architects, lighting designers, and manufacturers, all of whom fit together as important pieces of the puzzle. And like all designs, several iterations may be required, with input from all of these actors, to achieve optimal CS performance. If your design does not meet the criterion CS, try altering one of the components from the diagram in Figure 6. Keep in mind that the design must meet all visual criteria established by organizations such as the Illuminating Engineering Society.

Putting it all together

The varied intricacy and difficulty of visual tasks performed in patient rooms also call for varying lighting specifications. Generally, the higher the light level, the faster the visual system can convert optical stimuli into usable information (Chan et al., 2012). For tasks involving objects that are very small or have low contrast with their environment, high horizontal illuminance (measured on the workplane) levels (> 1000 lux) are required. For tasks involving larger objects or those that have suitable contrast with the environment, where increased light levels provide diminishing returns, low-level ambient lighting (100–200 lux) is acceptable (Chan et al., 2012).

Glare caused by electric lighting, daylight, reflective surfaces, and other sources can be avoided by selecting the appropriate luminaires and making interior design changes within the space. Indirect light sources can be

FIGURE 6



	ARCHITECT / LIGHTING DESIGNER STEPS		MANUFACTURER STEPS
1	Occupant type is the most important factor when determining the lighting for circadian design.	1	The type of luminaire will determine the effectiveness of getting the desired CS at the eye.
2	Create a 24-hour CS schedule that promotes circadian entrainment. CS should be ≥ 0.3 during the day (or at least for 3 hours in the morning) and < 0.1 starting 2 hours prior to bedtime.	2	Luminaires can be plugged into an outlet or mounted to the ceiling, walls, or furniture. Creating layers of light can provide the desired aesthetics, task illumination, and circadian-effective light.
3	Information about the size of the room, ceiling height, and material and surface reflectances will aid in determining what type of luminaires are needed and how light will interact with the space.	3	Intensity distribution provides an idea of how light will be distributed in the space.
4	Furniture layout can determine the occupant's field of view and allow for strategic placement of luminaires. If the occupant's location is not known, opt to maintain the same vertical CS levels throughout the entire space.	4	Luminaires can be classified as direct, indirect, direct/indirect, semi-direct, or semi-indirect.
5	Determine what type and how many luminaires are needed in the space based on room dimensions, and the luminaire's intensity distribution and lumen output.	5	Light sources rated as having the same CCT usually have different SPDs, and therefore will result in diff erent CS. Always use the SPD (not the CCT) and light level at the eye to calculate CS.
6	CCT impacts the atmosphere of a space by providing a warm or cool feel, but for circadian-effective light, you will need to use the SPD provided by the manufacturer or measured in the space.	6	Lumen output helps determine how many luminaires will be needed to achieve the target CS. High lumen output luminaires will help reach the target CS with fewer luminaires, but may cause glare.
7	CS is calculated using vertical illuminance and the light source's SPD. To modulate CS during the day, either use a tunable system that changes the SPD and light level or simply use a dimmer to reduce evening light exposure.	7	Separate lighting switches, dimming controls, and/or a color-tunable system helps with achieving the target CS, which is higher during the day (especially in the morning) and lower in the evening and at night.

Summary of considerations that designers and manufacturers need to account for when designing for the circadian system.

used to avoid glare while still meeting visual and circadian requirements, and other sources of glare can be reduced or eliminated by selecting nonreflective finishes for surfaces, altering window locations, and using window blinds. Finally, color rendering is another important consideration for luminaire selection, as accurate color perception is crucial for caregivers' patient diagnoses.

Patient room lighting that provides a robust 24-hour light-dark pattern can have profound positive effects on patient recovery. Lighting for patient rooms should be designed to promote circadian entrainment, providing high CS during the day and low CS in the evening, in order to increase patients' sleep times and improve their sleep quality. Nighttime lighting should be conducive to patient sleep while also accommodating visiting families and permitting caregivers to perform their tasks. Circadian lighting schemes have been shown to be effective for improving sleep in hospital ICU patients (Engwall, Fridh, Johansson, Bergbom, & Lindahl, 2015).

Due to the nature of the population, their temporary removal from the familiar surroundings of home, and the dynamic nature of the hospital environment, circadian rhythm disruption is not uncommon among hospital patients. The patient's health conditions (e.g., psychiatric and neurodegenerative diseases) can also lead to circadian rhythm disruption, as can critical illness generally (Oldham, Lee, & Desan, 2016). Environmental influences such as ambient lighting in patient rooms can also disrupt the circadian system. A study conducted in three intensive care units found that patients typically sleep for only about 6 hours over a given 24-hour period, with only half of that sleep time occurring at night (Gabor et al., 2003). Improving and increasing nighttime sleep by promoting entrainment of a patient's circadian rhythm to a robust light-dark cycle can lead to improved health outcomes (Engwall et al., 2015).

The recommended lighting pattern (Table 1 and Figure 7) for patients over the course of the day begins with a CS of 0.3 in the morning for at least 3 hours, drops to a CS of 0.2 for the midafternoon, and then drops once again to a CS of 0.1 in the late afternoon through the evening until bedtime. After bedtime, room lighting should be turned off, and nightlights should be added to permit safe navigation. This schedule can be accomplished using lighting designs that employ either static or tunable CCT systems.

TABLE 1

Time of day	CS
7–10am	0.3
10–11am	0.3 → 0.2
11am–4pm	0.2
4–5pm	0.2 → 0.1
5pm–end of day	0.1

Recommended lighting pattern for hospital patient rooms to promote circadian entrainment.

FIGURE 7

Figure 7: Simulations of hospital room lighting delivering high CS in the morning (left), medium CS in the afternoon (middle), and low CS in the evening (right).

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Eliminating hot water handwashing: Five reasons to act

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ABSTRACT

Health care planners, architects, and providers should consider eliminating hot water from handwashing fixtures for the following reasons:

1. Contrary to some prior suggested guidance, hot water is not required for effective handwashing.
2. It is arguably an unnecessary expense.
3. It wastes energy.
4. It presents potential risks for patients and health care providers.
5. There are cheaper and safer design options for water systems that are as effective for handwashing.

Hot water is not required for effective handwashing

Over the last several years, experts in infection control have been uprooting old assumptions that hot water is an essential component in handwashing. The World Health Organization (WHO) says, "Apart from the issue of skin tolerance and level of comfort, water temperature does not appear to be a critical factor for microbial removal from hands being washed."[1] The US Centers for Disease Control and Prevention (CDC) published guidance stating, "The temperature of the water does not appear to affect microbe removal; however, warmer water may cause more skin irritation and is more environmentally costly[2]. Water in the temperature range we can tolerate is not hot enough to kill bacteria. Water would have to be scalding hot before its temperature could improve upon the simple act of scrubbing with soap.[3]

Hot water for handwashing is an unnecessary expense

Health care planners and architects should examine the cost-benefit aspect of using hot water for handwashing. Availability of hot water is important for health care-related areas, such as soiled utility rooms, sterile processing, and food service, where very hot water is effective in sanitizing surgical and procedure tools and removing food service-related soil and grease. Hot water is also clearly beneficial for patient and staff showers, where full-immersion bathing calls for water temperatures to be higher than body temperature for comfort. The cost associated with these systems can be considered money well-spent. However, in terms of feet of pipe and energy use, the bulk of the hot water distribution system is designed, installed, and maintained to provide water to handwashing fixtures. From my personal experience, a recently completed 198-bed hospital in California has 693 handwash fixtures spread throughout the facility to meet the requirements of the California building code. By the guidance of the CDC and the WHO, the functionality of those 693 fixtures is not improved by supplying them with hot water—except for the added comfort.

A typical hospital domestic water system requires a two-pipe system to bring "cold" water (water at roughly the same temperature as the municipal system) and "hot" water (water at or over 110° F or 120° F, depending on the applicable code) to every hot water-using fixture in the building. This equates to thousands of feet of insulated pipe in a midsize hospital or medical office building.

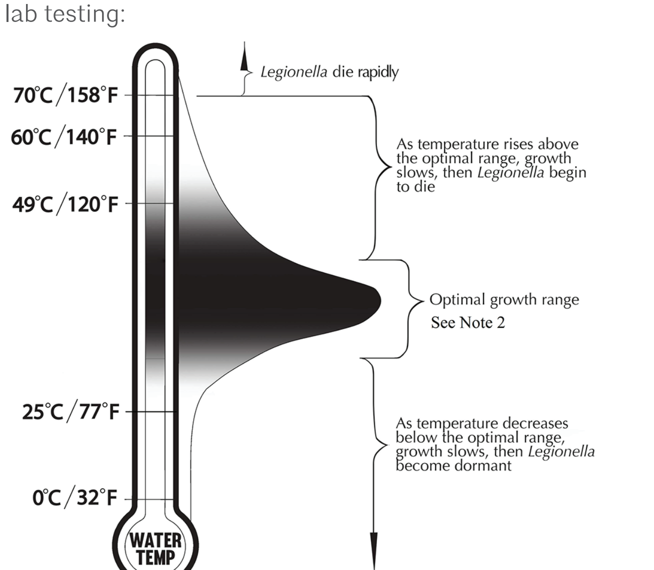
Hot water systems for handwashing waste energy

Throughout all that piping, energy is constantly being wasted by heat loss. Even though the tanks and piping may be well-insulated, the system will constantly dissipate heat into the building. That heat loss is compensated by adding more heat back into the water. This requires circulating pumps and more piping to bring the hot water back to the water heater so it can be reheated. In a hospital, this process of circulating and reheating is a 24/7/365 operation.
A Vanderbilt Institute for Energy and the Environment study indicated that if everyone in the US washed their hands in cooler water, it would equate to eliminating the energy-related carbon emissions of 299,700 homes. Nearly 800 billion handwashes performed by Americans

each year result in more than 6 million metric tons of CO2-equivalent emissions annually.[4] Unfortunately, we do not have data available that separates hospital hot water energy used for handwashing versus other hot water uses. However, it may be possible to gather this granularity of data in the future through smart-sensor faucets.

Potential risk to patients and staff

Poorly designed and/or maintained hot water systems can host waterborne pathogens. These include Giardia, Cryptosporidium, and the current leading cause of US waterborne diseases, Legionella.[5] Under the right conditions, Legionella exposure can lead to infection and Legionellosis, a potentially fatal illness.[6] We know that Legionella is naturally present in our water systems, and it is usually not a public health problem—unless the water is warm enough to support amplification and maturation of the bacteria. Stagnation can contribute to this as well. ANSI/ASHRAE and the National Sanitation Foundation (NSF) have put a tremendous amount of effort into developing standards and guidelines for the industry to mitigate risks related to waterborne pathogens like Legionella. One of the more difficult aspects of that effort has been trying to define the temperature ranges that support pathogen growth. Part of the challenge is the nature of testing—typically conducted in laboratory settings that do not reflect the conditions in operating buildings. Variable environmental conditions, including water quality, temperature, and the nature of biofilm in the piping system, cause difficulties in accurately predicting a pathogen's behavior within various temperature ranges. That said, the ASHRAE Guideline 12, "Managing the Risk of Legionellosis Associated with Building Water Systems," provides this graphic with the understanding that it is based on lab testing:



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Poorly designed hot water systems may include dead-end branches of piping to fixtures and/or poorly circulated piping loops that result in water temperatures that hover in the range where pathogens can grow to dangerous levels. In addition, providing hot water for handwashing nearly doubles the volume of water waiting to be used at fixtures. This increases the amount of time water spends in the building piping system before it is replaced with fresh water. The longer water sits in pipes, the more the disinfectant from the municipal system dissipates. This can also contribute to waterborne pathogens growth and infection control problems. By not heating the water to the range where Legionella thrives, the system behaves much like the cold-water system, in that Legionella bacteria remain largely dormant.[7]

Given the detrimental effects of using hot water for handwashing, why would any plumbing code require it? The mission of code authors is to protect the public's safety. Toward that end, the two most prominent model plumbing codes—the Uniform Plumbing Code (UPC) and the International Plumbing Code (IPC)—limit the maximum safe temperature of water coming out of showers and bathtub fillers, etc. to prevent conditions that could expose people to scalding-hot water. The IPC requires hot water at a temperature equal to or greater than 110° F for "bathing and washing purposes" in commercial buildings. That is generally interpreted by AHJs and design engineers to include handwashing. One might assume this minimum temperature is codified either to ensure comfort for bathers, or it is an unexamined assumption that it is effective in preventing growth of pathogens in piping and/or the removal of bacteria from hands.

The UPC states: *"Hot and Cold Water Required. Except where not deemed necessary for safety or sanitation by the Authority Having Jurisdiction, each plumbing fixture shall be provided with an adequate supply of potable running water piped thereto in an approved manner, so arranged as to flush and keep it in a clean and sanitary condition. …"*[8] The UPC defines "hot water" as exceeding or equal to 120° F. The UPC does not clearly require hot water for handwashing fixtures; however, in my experience, AHJs generally interpret the code's intent as having the water up to each fixture hot enough to limit pathogen growth and that further code provisions, such as mixing valves, prevent water over 120° F from leaving the faucet and creating a scald risk. It appears to me the intent is that if you are going to provide hot water to a handwash fixture, you must have a minimum temperature serving it to prevent pathogen growth, and you must have a maximum temperature leaving the faucet to prevent scalding.

For reference: The ASHRAE Handbook on service water heating lists the "typical temperature requirement" for handwashing lavatories as 105° F.[9]

The Facilities Guidelines Institute (FGI), an independent, not-for-profit organization dedicated to developing guidance for the planning, design, and construction of hospitals, outpatient facilities, and residential health, care, and support facilities, is very clear in its stance on this subject. FGI guidelines state: *"*(b) For hand-washing stations, water shall be permitted to be supplied at a constant temperature between 70°F and 80°F using a single-pipe supply. For showers and other end-use devices requiring heated water, water shall be permitted to be supplied by this low-temperature circulation system and heated with point-of-use heaters. A2.1-8.4.2.5 (4)(b) One way to limit the potential growth of Legionella in a heated potable water system is to distribute water at a temperature of less than 80°F (26.6°C) for hand-washing use. Water at this temperature may be warm enough to encourage good hand-washing practice but cooler than the ideal growth conditions for Legionella."*[10] Many states have adopted the FGI guidelines, but it remains to be seen if this section will have traction.

There are cheaper and safer design options for water systems that are as effective for handwashing

I propose a single pipe system to deliver 75° F water to the handwashing fixtures in a hospital or clinic. For this argument, I am proposing 75° F because that temperature is high enough so as not to seem "cold" to most of us while low enough to avoid Legionella amplification and maturation.

Several benefits of using this single-pipe, single-temperature approach include:

- No reduction in efficacy of handwashing—if the regular protocols are followed
- Reduced water heater size
- Reduced energy used to heat and maintain water temperature
- Reduced amount of piping, valves, hangers, and mixing valves
- Reduced insulation installation
- Reduced maintenance on point-of-use mixing valves and faucets
- Reduced overall volume of water in pipes = less water age and related waterborne pathogens in the system
- Reduced overall volume of biofilm that can harbor waterborne pathogens
- Reduced infection control issues at faucets
- Reduced dermatological impact of frequent washing

There are several possible ways to design a system. For example, if your municipal water supply comes into the building at 50° F, you could use a variety of energy sources to increase the temperature to 75° F and send one branch of that water to the handwashing fixtures. That piping would not require insulation or recirculation if properly sized. You could also route the piping to have a toilet at the end of the line, so the occasional flush keeps fresh water coming into the system. Another branch of the 75° F water would be used as preheated cold-water makeup for the regular hot water system's heaters. You would still want to have cold water for most of the toilet flushing and tempering of hot water at showers, etc. However, a large portion of the hot water infrastructure could be eliminated.

For many hospital buildings, the lower floors house diagnostic and treatment functions, while the upper floors are typically patient floors. These are often split into two pressure zones, with street pressure serving the lower floors and boosted-pressure systems for the patient floors. For these, using a central hot water system for the patient floors may be sensible (particularly given the showers) with localized heaters for the diagnostic and treatment areas. Point-of-use heaters could play a role in some scenarios as well.

The water heat sources (aiming for 75° F) could include a variety of creative options, such as waste heat from HVAC systems or data centers or drain line heat recovery from sterile processing, etc. Every building type and location will have different characteristics and different design approaches that warrant different solutions. For some, this system may not be a good fit or perhaps 70° F is preferred. Some localities have municipal water temperature closer to 75° F, in which case, a single-pipe, single-temperature system for handwashing and toilet fixtures would be most appropriate, thus eliminating even more piping.

Health care planners should consider these reasons to eliminate hot water from handwashing in health care settings:

1. Contrary to some prior suggested guidance, hot water is not required for effective handwashing.
2. It is arguably an unnecessary expense.
3. It wastes energy.
4. It presents potential risks for patients and health care providers.
5. There are cheaper and safer design options for water systems that are as effective for handwashing.

Architects and engineers should work with their health care clients and code authorities to foster a new attitude about how we use resources in our building systems. If we uproot outdated assumptions and take a fresh look at our codes, how they are being interpreted, and how they may be inhibiting healthy innovation, we may be able to take this one positive step.

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Urban interventions to mitigate the adverse effects of occupational stress in office buildings

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ABSTRACT

As the world's urban population continues to grow, so does the number of white-collar jobs that require employees to spend most of their waking hours in office buildings. It is more important than ever, therefore, to attend to those aspects of urban life that have significant effects on people's health and well-being. Work-related stress is one such risk factor, both for employees' mental and physical health as well as for organizational productivity. Although the sources of such occupational stress are varied, one significant contributor is the built environment. To mitigate occupational stress, there are, fortunately, three areas in which intervention through the built environment can be affected: architecture, the urban landscape (conjoined space), and urban planning. Of these three, the present paper focuses on urban planning factors, which can impact considerably the two other areas. In the beginning, I discuss the significance of the problem on both the individual and organizational levels and then explore the relationship between urban planning—and, specifically, the components of office placement and programming—and occupational stress. I then offer a set of strategies for mitigating stress that can be instituted during the early stages of the planning process.

Introduction

Occupational stress has been a research topic in fields as diverse as health care, public health, neuroscience, psychology, social sciences, urban studies, environmental studies planning, medical sciences, and management. Fortunately, mental health is receiving more attention in architecture in recent years. However, most studies on occupational stress focus primarily on the general well-being of workers, addressing concerns such as productivity, satisfaction, and mental health; occupational stress is not typically the main focus. Isolating occupational stress as a primary risk factor is the main focus of this article. To address this gap in contemporary research, in this article, I identify the relationship between occupational stress and the built environment in the workplace during the planning stage through a systematic cross-disciplinary literature review.

Occupational Stress are mainly caused by psychological demands and lack of decision-making autonomy (WHO, 2002). Occupational stress occurs when an individual loses control over employment demands (Wright, 2007). If stress occurs frequently, it will cause distress, which itself is a condition of physical or mental suffering (Figueroa-Fankhanel, 2014). Further, distress can be classified as psychological, medical, and/or behavioral.

At the personal level, medical distresses are well-studied. Chronic stressors are associated with the destruction of both cellular and humoral procedures that can lead to heart disease, cancers, and musculoskeletal injuries, along with related discomfort and disability (Quick & Henderson, 2016). At the organizational level, personal distress can greatly reduce the productivity of an organization due to an accumulation of personal dysfunctions or simply worsened work performance. Indeed, studies conducted in North America over the last decade have established that the work environment has a significant impact on employees because they spend at least 50% of their indoor time in the workplace (Fleury-Bahi, Pol, & Navarro, 2017). Occupational stress's adverse effects on the organization manifest as absenteeism, labor turnover, disability, and productivity decline (Czabała, Charzyńska, & Mroziak, 2011; Palmer & Dryden, 1994).

In a systematic review on productivity research studies and occupational stress, two main categories were identified for productivity improvement: (1) individual task productivity and (2) collaborative and teamwork productivity (Vischer, 2003). When it comes to individual tasks, lowering the stress level of employees might result in a higher quality of outputs, lower absenteeism rate, and in general, higher turnover (Vischer, 2003). Similarly, lower maintenance costs, lower error rates, smaller groups, cost reduction, better decision making, and fewer client complaints were found to be the result of mitigating the occupational on the collaborative and teamwork productivity in any organization (Vischer, 2003). Since most of an organization's operating costs are related to its staff, improving staff productivity by even as little as 1% can have a significant impact on the bottom line and a business's competitiveness (WGBC, 2016).

Social determinants of health

The social determinant of health (SDOH) is an important factor in public health studies. The World Health Organization (WHO) defines SDOH as "the [set of] conditions in which people are born, grow, live, work and age" (WHO, 2012). Age and gender have emerged as particularly popular factors to investigate in recent occupational health studies. However, these recent studies, particularly those conducted by epidemiological researchers, have yielded a variety of findings, some of which, unfortunately, contradict each other. For instance, Kivimäki and Kawachi found that health differences between men and women, between younger versus older employees, and between workers from varying socioeconomic backgrounds appear to be small (Kivimäki & Kawachi, 2015). By contrast, Zsoldos and colleagues found a direct relationship between aging and experiencing occupational stress (Zsoldos, Mahmood, & Ebmeier, 2014). Their study shows that by aging, employees often become more vulnerable to stressors and face more age-related diseases and, as a result, choose to take early retirement. Moreover, older employees who are members of ethnic minority groups are more likely to face bullying and discrimination, which are extreme stressors (Zsoldos, Mahmood, & Ebmeier, 2014). Other groups who face high levels of stress are members of the working classes, immigrants, seasonal workers, and blue-collar workers (Li et al., 2015) since they have less control over their environment than do members of more privileged socioeconomic categories (Aronsson, 1989).

Another area that remains understudied is that of work-related stress and health problems in women, particularly. Among the few such studies, one of the more important was conducted by Beil and Hanes, who measured changes in salivary amylase (an enzyme) and the relationship between those changes and self-reported stress, finding higher stress levels in women than in men (Beil & Hanes, 2013). Interestingly, a study by Nielsen and colleagues found no association between stress and mortality among women; further, to their surprise, these researchers even found that highly stressed younger women are less vulnerable to cancer mortality than their male counterparts (Nielsen et al., 2008). This same study showed, though, those younger men were found to be at greater risk for stress-related cancer than were older men. Its authors concluded that greater attention should be given to prevention strategies for those presumably healthy men who face stress as a risk factor for premature death during middle age (Nielsen et al., 2008).

Despite these various contradictory findings, important consistencies have also been discovered. For example, many studies have shown that the risk of severe mental illness is higher in cities than in rural areas (Gruebner et al., 2017). That is why the focus of this article is on how environmental factors, such as location, adjacencies, and transportation, predominate in urban areas and contribute to occupational stress.

Areas of intervention in the built environment

One of the areas of focus of public health, a growing, and increasingly multidisciplinary field, is the built environment and its role in social, economic, and medical policymaking. This should not be surprising, as public health professionals, more than ever, are involved directly in those aspects of community and community-based design that are related to architecture. As a result, architects, planners, designers, and other contributors to the creation of the urban built environment are increasingly aware of their role in supporting people's health and well-being. Interventions to mitigate occupational stress need to be implemented at the levels of urban planning, policymaking, and site selection. Architectural intervention can then complement and complete stress mitigation strategies.

Fortunately, the importance of well-being and health is acknowledged by the industry and the market. In an AIA white paper, for example, the authors show that nearly three-quarters of US architects acknowledge that the health impacts of buildings influence their design decisions (Tinder & Schneidawind, n.d.). At the same time, standardization systems such as ULI, LEED, and WELL indicate that there is a high demand from owners and investors for healthier buildings.

Interventions for mitigating occupational stress in the built environment have been studied in three separate but inevitably related contexts: architecture, urban landscape (conjunct space), and urban planning (Diagram 1). Fortunately, there is a robust body of literature on urban and architecture interventions, including those based on the evaluation of physiology and biophilia hypothesis. While many factors contribute to occupational stress, research consistently shows that the primary factors are lack of control, night shift, the disproportion in effort-reward, high demands, poor work environment, social isolation, inactivity, and violence at work (Härmä, Kompier, & Vahtera, 2006; Smith & Beaton, 2008). One of the main causes of occupational stress is losing control over one's environment, which can impact organizations both on the individual and the collective level (Aronsson, 1989). Control here means that "individuals have to determine the influence on outcomes"(Aronsson, 1989). Environmental satisfaction, which impacts the psychological needs of employees, is another important factor; as researchers have shown, environmental satisfaction and stress have an adversarial relationship with each other (Tomba Singh, 2014).

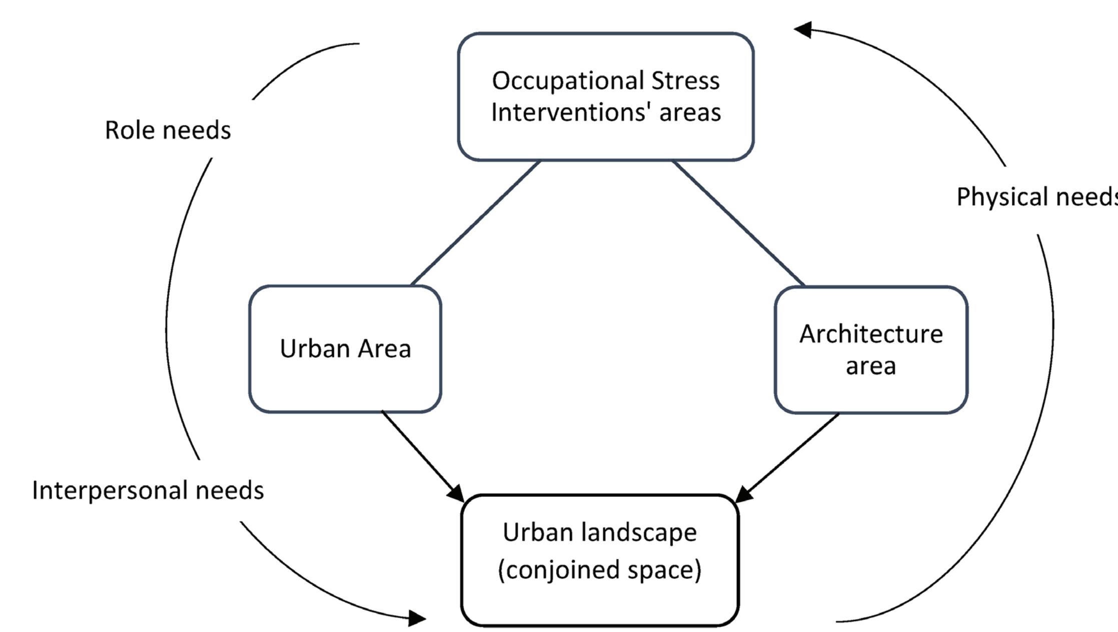
Recent studies have identified four broad categories of workplace demands that cause distress: (1) task demands (occupation, careers, workload, job insecurity); (2) role demands (role conflict and ambiguity); (3) physical demands (temperature, lighting, workplace design); and (4) interpersonal demands (social density, personality conflicts, leadership style, group pressures) (Brown & Richerson, 2014; Quick & Henderson, 2016).

These four categories can be used as a framework for categorizing the design strategies for mitigating the occupational stress of employees. Task demands and physical demands relate to, or limit, the comfort level of employees; these include temperature-, light-, and sound-related strategies. Designers should also consider the physical needs that humans have to affiliate with nature. Access to nature can be either passive or active, engaging any or all of our senses (Winterbottom & Wagenfeld, 2015). Other strategies can focus on social behaviors and interpersonal demands, which mostly concern buildings' interiors. However, when it comes to role demands, either personal or occupational, the urban configuration can play a significant part in mitigating tension caused by managing those roles. (See Diagram 1).

The urban sector

In this section, I address the factors that cause stress on employees at the urban scale. In the urban context, the focus of recent research has been on location, general situation, and adjacencies, acknowledging that stress is an evolutionary response to the threat. Mitigating the adverse effects of stress in the urban context can be addressed by biophilia strategies. Biophilia is a hypothesis based on humans' intrinsic tendencies, both neurological and physiological, to affiliate with nature (Browning, Ryan, & Clancy, 2012). To execute a biophilic design strategy, the building, occupants, location (context), and functional aspects of the design must be taken into consideration (Gillis & Gatersleben, 2015). In other words, the biophilic design should not be a temporary or isolated experience; rather, it must be a part of a comprehensive system that works with nature (Kellert, 2015). To achieve biophilic design, natural features must be considered in all areas of design in order to provide beneficial results for people (Kellert, 2015). Having more access to natural elements and more greenery in an urban area, for example, leads to a greater ability to cope with chronic stress. (See Diagram 2.)

DIAGRAM 1

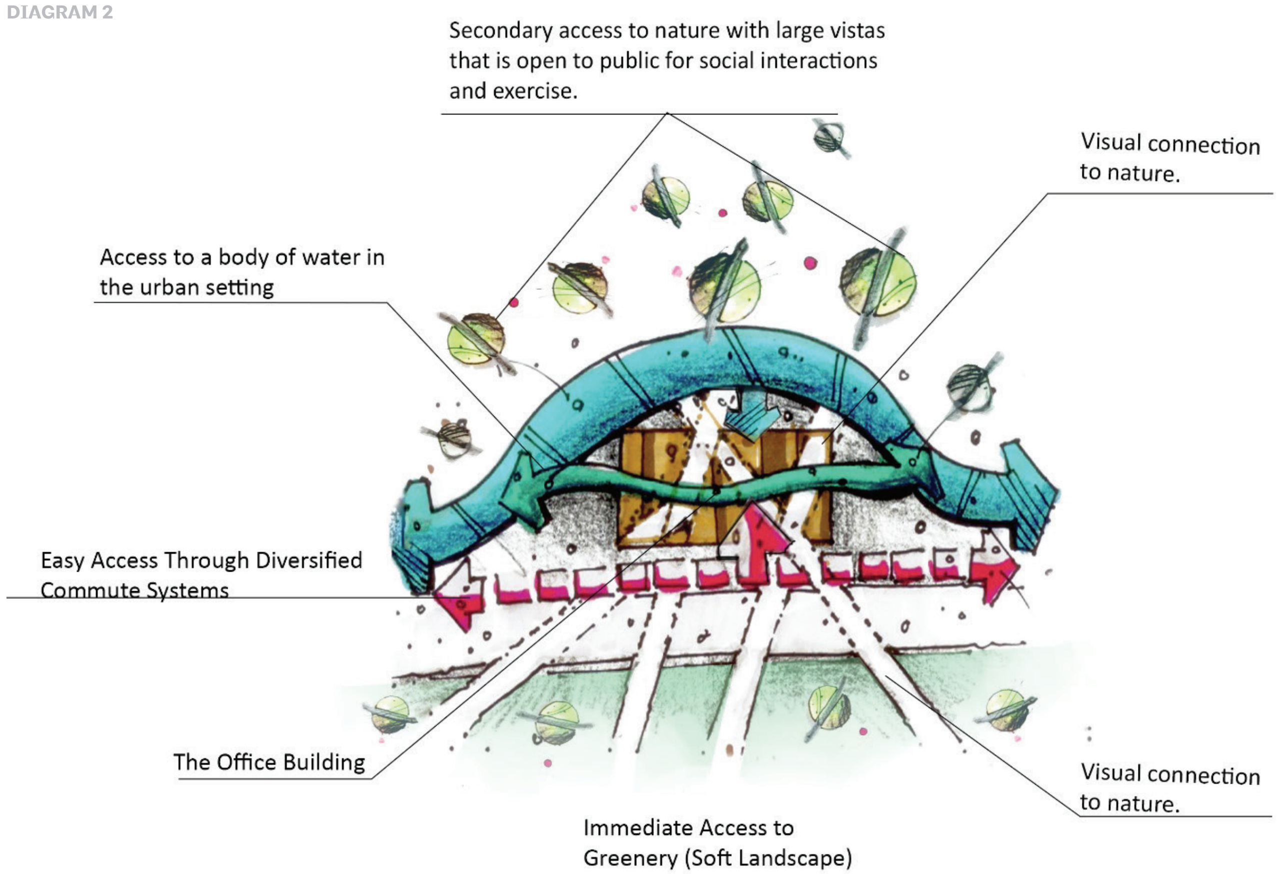


The relation between areas of intervention, office buildings, and human needs.

Another problem that causes mental stress for employees can be explained by the prospect-refuge theory, an environmental pattern that is the result of a delicate balance between frame and vista that stimulates a sense of mystery, comfort, and safety (Dosen & Ostwald, 2013). Avoiding enemies, as part of human evolution, is fundamental to this theory, which explains that human preferences are based on the superior response to threats and the apperception of a greater chance of safety (Stamps, 2014). Dosen and Ostwald (2013) identified four main elements of prospect-refuge. The first two, prospect and refuge, are interlocked and must coexist. Prospect is defined as the outlook, vista, or view, while refuge is the setting or context within which a person experiences the prospect (Dosen & Ostwald, 2013). The third factor is the sense that safety may be either real, implicit, imagined, or symbolic; a sense of comfort is the product of the balance between prospect and refuge (Dosen & Ostwald, 2013). The last factor is the complexity of a setting in terms of experimental and visual vibrancy (Dosen & Ostwald, 2013). An environment with restorative (healing) effects has high levels of prospect (open view and clear vision) and high levels of refuge (hiding); by contrast, the environment with a low prospect and high refuge level will increase stress dense urban settings, such as the downtown areas of large cities, the prospect can be very limited, both inside and outside of buildings. Even plazas in such cities are often surrounded by a cluster of skyscrapers that limit the vista in all directions.

Perceived environmental threats include air, water, and noise pollution; specific urban designs, such as tall buildings, that may be felt to be oppressive; and physical threats, such as accidents and acts of violence (Aronsson, 1989). Avoiding locations with these conditions is the initial step in the process of mitigating occupational stress. The dense urban built environment, without green open spaces or even views of natural elements, threatens the mental health of employees (Beil & Hanes, 2013). The next step in reducing the risk of occupational stress is increasing worker control on the individual as well as the collective level. The structure of control at work is dictated by production techniques, legislation, and management strategies (Gruebner et al., 2017). Although the designer's role in increasing the employee's sense of control is limited, providing various options for commuting and socializing and making available access to nature can improve the sense of control of employees on this scale.

DIAGRAM 2



Providing the connection to nature both visually and physically.

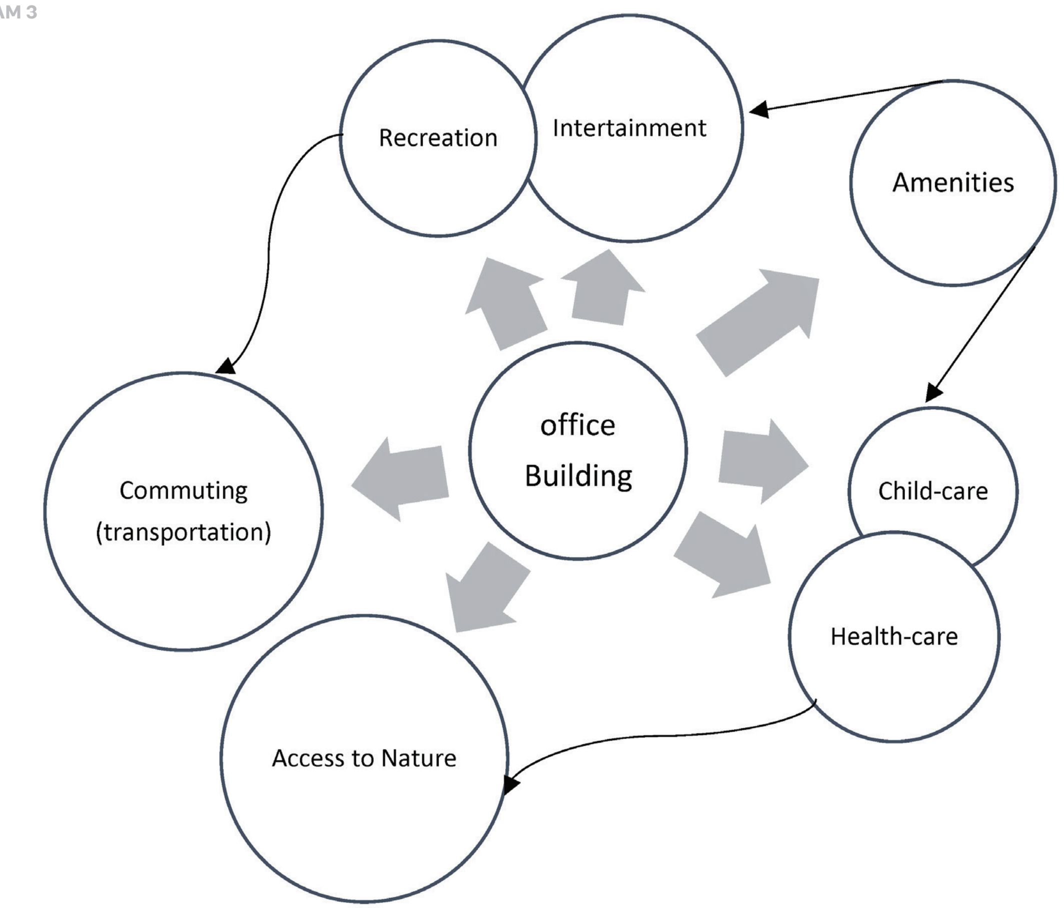
Social isolation is also a reliable predictor of perceived stress (Ward Thompson et al., 2016). A study by Melis and colleagues, for example, found that urban sprawl and the absence of public transportation caused depression due to the fact that people had a lower chance to move around and have an active social life (Melis et al., 2015). By contrast, other recent research shows that social interaction can improve the productivity of the organization. Interaction among employees can take place outside; making available easily accessible green spaces can promote such interaction (Ward Thompson et al., 2016). Although social interaction as an intervention has multiple aspects, the location, entrance, and orientation of the building and adjacent facilities are important factors in its success. A practical strategy for office buildings is providing access to open spaces during breaks (Al Horr et al., 2016). Furthermore, granting easy access to amenities and public infrastructures such as child care, recreational and entertainment spaces, and parks can reduce environmental stressors (Al Horr et al., 2016). (See Diagram 3.)

Another critical factor that affects workers' stress levels is the level of satisfaction or dissatisfaction they experience during their commutes. However, research on this topic has yielded findings that are inconsistent and even contradictory. Haider, Kerr, and Badmi (2013) found that enduring frequent traffic congestion and experiencing longer-distance commutes increases stress levels The type of vehicle or mode of transportation that workers use when commuting can also contribute to stress. Also, Gatersleben and Uzzell report that car users feel more stressed than those who depend on public transportation, while those who bike or walk to their workplaces are less stressed (Gatersleben & Uzzell, 2007).

Conclusion

The significant role of the urban built environment on the mental health of individuals is undeniable; however, mental stress remains a major risk factor usually overlooked in the programming stages of design and site selection. The few urban-planning-related interventions that have been put forth have been limited in both their scope and their quantity, since solutions to the problems they discuss would, in order to be effective, necessarily involve many

DIAGRAM 3



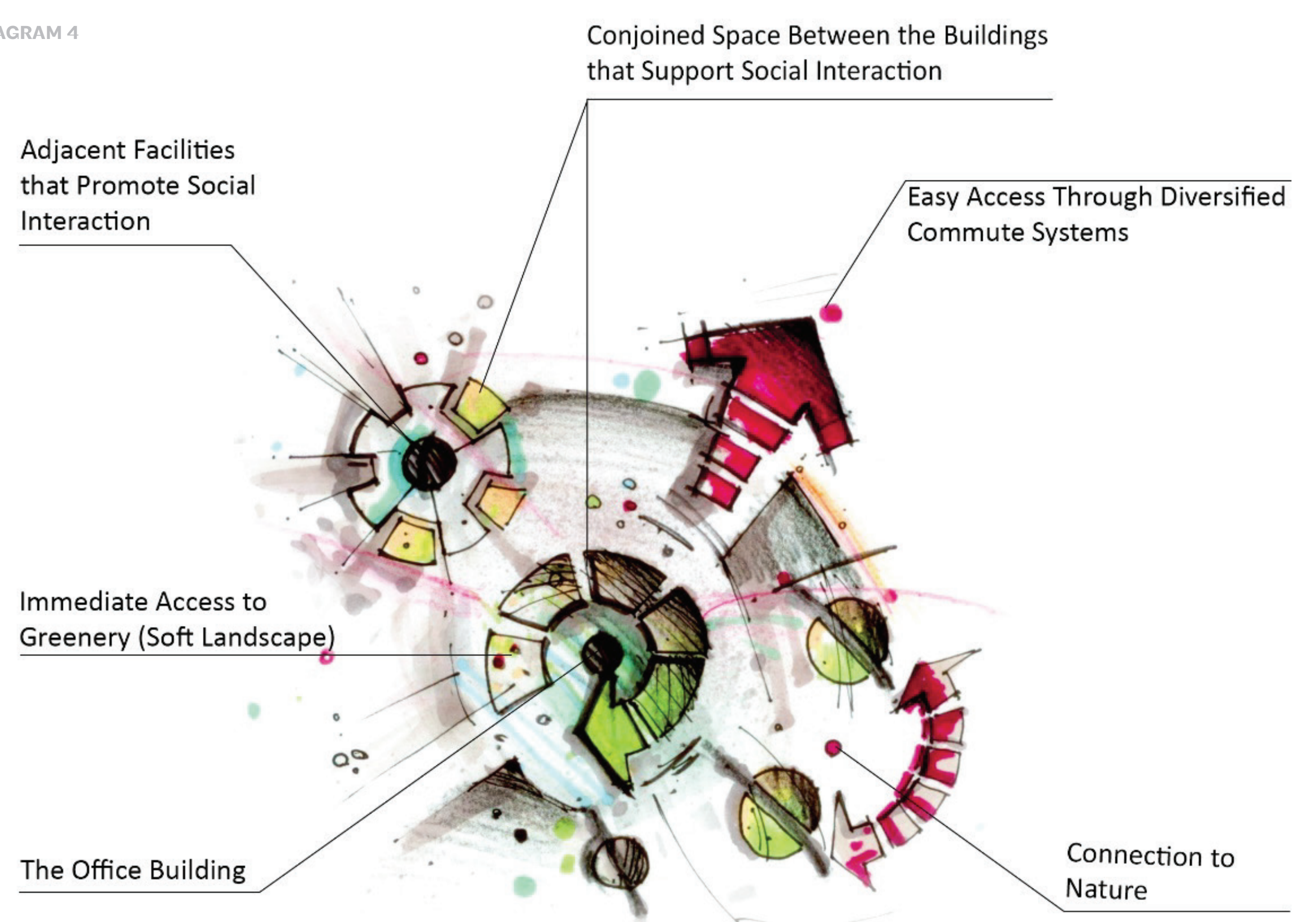
Relationships of office buildings in an urban setting with stress-mitigating factors.

other categories of stakeholders and decision-makers than have been consulted up to this point. However, architects, by acknowledging the factors that contribute to workplace-related stress, can provide informed consultations to their clients. Indeed, understanding the conditions that can lead to or exacerbate occupational stress can be crucial when developing master plans for large corporations, their site selection, and the design of their office complexes during the programming phase. (See Diagram 4.)

As discussed above, having access to nature, visually and physically, is one major recommendation for mitigating mental stress in the site selection process. While advocates of biophilia theory have explored these issues extensively, certain aspects of biophilic design remain vague. In biophilic design, "nature" refers primarily to green landscapes—but other types of natural settings, such as those in white landscapes (glaciers, mountains, and water) and black landscapes (lava fields) (Brooke & Williams, 2020) have not been studied to the degree that would allow conclusions to be drawn regarding their effects on mental well-being. For this reason, I recommend considering sites representing a wider variety of natural settings, especially in light of research showing that different groups of people, with different social determinants of health, do not feel comfortable in the same types of natural environments (Doughty, 2018). For example, densely wooded areas might have healing effects on one group of people (Gatersleben & Andrews, 2013) while causing tension for others (Milligan & Bingley, 2008).

The urban context, the locations of office buildings and adjacent facilities, and their amenities all play a major role in employee satisfaction and well-being (Al Horr et al., 2016). Adjacent facilities, such as those offering services or entertainment, can improve the satisfaction, health, and productivity of employees on various, interconnected levels. However, sometimes, having attractive natural features means that a site may be isolated from other services and far from major urban developments. Thus, finding the right balance between access to nature and the proximity of urban amenities requires a case-by-case study.

DIAGRAM 4



An example of an urban setting that can improve the mental well-being of employees by mitigating occupational stress.

Recent studies show that transportation in the urban environment can further contribute to the experience of mental stress. Being conscious of the impact of transportation type on employees' mental stress is crucial for decision-makers. Moreover, since studies show that time spent in traffic jams and longer transportation have a direct relationship with mental stress, project directors should choose sites with easy access, low-traffic roads, particularly when developing a site within the urban environment. Moreover, companies that promote walking and biking as transportation options will have less-stressed and healthier employees. Developing such commuting strategies requires a case-by-case study of the employee context, the urban infrastructure, the local context, feasibility, and organizational culture in addition to the the diversity of commuting options.

Finally, social interaction—and the ways that urban planning can enhance such interaction and thus increase employees' well-being and satisfaction—is also a crucial component that must be borne in mind during the programming phase of the design process. Doing so will necessarily involve a combination of other interventions. Giving workers the freedom to interact with others—and to conduct other essential daily activities—outside of the building can help improve their perceived quality of life. Social isolation can lead to stress and reduce productivity (Ward Thompson et al., 2016); thus, having options for a social life outside the building can reduce these risks. One practical intervention in the urban context is to include public plazas, with amenities and soft landscapes, that are open to the public and that are thoughtfully integrated with the fabric of the surrounding city. This provides an additional opportunity for social interaction outside of the building, among other advantages. However, designing a successful plaza in a dense urban context is challenging, especially when it comes to enhancing physical and mental comfort.

Health care workers are typically and routinely under high levels of occupational stress, including burnout. Such problems are exceedingly common among nurses, medical doctors, and other health care workers and can have adverse effects on their patients as well as on their own organizational outcomes (Clough et al., 2017; Khamisa et al., 2015; Basu, Qayyum, & Mason, 2017). Medical settings, and especially hospitals, are usually the work environments for members of these occupations. Even though such work environments already require specific architectural and occupational stress mitigation strategies, the various urban interventions to mitigate stress discussed in this article apply to health care workers.

Finally, many recommendations concerning the urban context already apply to other best practices recommendations regarding well-being and sustainability, such as LEED and WELL standard guidelines. Thus, the recommendations would fit in the scope of most of the projects. As mentioned above, the existing studies are not conclusive when it comes to mitigation of occupational stress, especially in the urban scale; therefore, it is crucial to have at hand the results of comprehensive experimental research on occupational stress and its relation to the built environment—research that considers architecture, the urban environment, and the conjunction area between them. This research should be categorized based on the various tasks performed by, and the various health detriments to, health care workers. Such research is especially necessary on public spaces and their restorative features, the minimum quantity of open spaces needed in order to be restorative to workers, the impact of different landscape types on occupational stress, and the effects of commutation modes and systems on workers' mental stress.

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Using choice-based design to improve health

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ABSTRACT

Using a new framework from the 2018 award-winning book Choice Architecture: A New Approach to Behavior, Design, and Wellness, we show how understanding human choice and action in architectural settings can reorient health care design from cure to prevention. Choice-based design can induce healthy actions in users via principles of rational choice and behavioral economics. The paper presents a way to design environments in a systematic and scientific way so as to influence a more holistic set of health-promoting behaviors in people.

The changing culture of health: caring for the mind and body

Could health-promoting and safe human behavior be influenced through physical design? Could the perceptual response to a designed environment be engineered to also influence spontaneous user choices? Could the perpetual gap between design intent and observed usage/behavior be narrowed? Does physical design have a role to play in enhancing population health? Despite spending about one-fifth of its national GDP on health, and having the largest health care spending in the world at an estimated $4.01 trillion in 2020[1], the US economy is under continual pressure to expand health services. A focus on human choice and agency offers the possibility for promoting human well-being and reducing health costs by shifting the focus from treatment to preventive health for individuals and communities.

Considering that our genetic contribution to health is roughly 30% and our social/behavioral/environmental contribution is roughly 70%[2], designers can have a deep impact on prevention if design is approached in the right way. Choice Architecture, a new framework, claims the emphasis should be on how people experience and interact with the built environment because our experiences and actions influence healthy choices, which in turn can improve our health. Its original and key idea is that the way to realize this orientation is to apply the principles of choice from economics to architecture.

The mainstream approach to choice in consumer economics since the 18th century has been rational choice based on costs and benefits. However, it turns out that people do not always choose rationally. The foundations of a broader behavioral approach to human decision-making were laid by Amos Tversky and Daniel Kahneman in the 1970s, for which the latter won the Nobel Prize in economics. Rational choice sometimes involves deliberation—an explicit analysis of net benefits—and is context-free; whereas, behavioral choice is often spontaneous and contextual. In some situations, the former appropriately describes a person's decisions regarding behavior and action, and in others, the latter appropriately describes the response. In fact, it could be argued that other than major life decisions, few conscious human choices follow a rational cost-benefit analysis. It is the unique strength of Choice Architecture to extend both sets of ideas to architectural environments.

It is well-known that architecture influences our moods and behavior and, therefore, our health. But people do not always make healthy choices, and it has seldom been clearly demonstrated exactly how this influence is realized.

Understanding this process can help architects design in ways that promote health. It is different from existing design approaches, which miss the importance of the choices people inevitably make when they experience the built environment. These choices impact their well-being in positive or negative ways. More specifically, while the connection between design and health has been well researched, decision-making in architecture, interior design, urban design, and landscape architecture has generally been founded on the belief that users always conduct comprehensive cost-benefit analysis using some rational framework. Encoded guidelines and codes, as well as designers' hypothesized outcomes, are founded

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2. Schroeder, S. A. (2007). We can do better: Improving the health of the Am*erican people. The New England Journal of Medicine, 357: 1221-1228.*

on a framework of rational choices and ideal behavior. Owing to this fundamental belief, designers have traditionally depended on observation data in predicting/measuring use of spaces, and its conformity or not with design intents. The fact that in many cases the actual use of spaces does not reflect those intended in design underscores the role of choice-making outside of the rational choice framework. The Choice Architecture framework can be used in all settings and with all users, individuals, or groups. It does not offer stand-alone isolated design and health solutions or design prescriptions, but components of a holistic response. The attention to human choice and agency offers the potential for reducing health costs as well as wholesome overall life experiences for individuals and communities. Simply put, the Choice Architecture framework can help designers create better engineered solutions with more precise predictions to reduce stress, improve well-being, enable human relationships, and promote safer settings in a self-sustaining way.

Choice-based design

Experience is a key concept that mediates the relationship between choice-based design and health. This model leads to a scheme where the built environment influences human agency to act in a needful way.

The scheme:
design element → experience/choice → action → health

Design induces experiences and choices from which individuals choose an action that affects health positively or negatively.

There are several rational and behavioral principles that govern how people make choices developed by economists. These can be extended to a deeper understanding of architecture.

While rational choices are made by optimizing net benefit as applied to users' own health (should I climb the stair or ride an elevator?), behavioral choices (should I linger or move on?) are spontaneous and reflect ideas such as relativity, status quo bias, nonlinearity, framing, availability, anchoring, representativeness, reference point shifts, and others.

A Choice Architecture framework offers an added layer of information during design decision-making that enables positive effects on health. For example, the presence or absence of factors in a specific context that influence user choices leading to the use of an attractive and accessible stairway or a light-filled room can drive precise design decisions to improve health/well-being. The key is in understanding the factors that influence rational and/or spontaneous decisions in the use of designed spaces. The table below lists some behavioral choice principles. The section following it will show two examples using choice principles in architectural settings.

TABLE 1

Behavioral Principles	Empirical findings on choices made when people are spontaneous in their actions
Framing	Choices change based on how the same information is presented in different ways.
Nonlinearity	People's actions are nonlinear.
Availability	Make the easy choice.
Representativeness	Jumping to conclusions based on a few representational cues.
Anchoring	Subsequent actions are anchored to initial actions.
Cost of zero cost	People inflate the positive value of free items and ignore the hidden cost.
Relativity	Choose between things that have comparable attributes.
Status quo	A preference for the existing situation at the reference point.
Reference-dependence	When value is defined by the gains and losses of an item relative to a reference point.

Applying choice-based design

Example 1: Rational choice—Take stairway or elevator
A hospital environment offers an attractive lobby with an easily accessible stairway for visitors and staff to promote their health and elevators for patients who need them. The underlying idea is to design rational choices for staff and patients to motivate them toward healthy actions.

Hospital lobby with stairway and rear elevators

Here are two scenarios, one with a hypothetical staff user and another with a hypothetical patient user.

Unlike other approaches, the rational choice model makes user preferences, the available choices, and the connection between them explicit. This allows different users to have different preferences and different available alternatives to choose from with different resulting actions in the same architectural environment.

The choices the lobby provides are to use the stairway or the rear elevators to the upper floors.

Staff scenario:
A staff member has the option to take the stairway or the elevator. She sees the stairway and the elevators daily and chooses to climb the stairs and improve her health. Here is how the rational choice between these two lobby elements can be made.

- Staff member evaluates climbing the stairway:
  - Benefits of climbing stairway = 6 units (e.g., reduction of blood pressure, reduced risk of stroke, increase in endorphins, views, improved mood, etc.)
  - Costs of climbing stairway = 2 units (e.g., added time, effort, etc.)
  - Net benefits = 6 – 2 = 4 units

- Staff member evaluates riding the elevator:
  - Benefits of riding elevator = 3 units (e.g., faster, less effort, etc.)
  - Costs of riding elevator = 1 unit (e.g., waiting in line, multiple stops, crowded, etc.)
  - Net benefits = 3 – 1 = 2 units

The stairway and elevator can be given utility numbers (using choice theory) that capture the overall user benefits. The staff member represents her more preferred actions with higher utility numbers and less preferred actions with lower utility numbers.

The staff member makes a list of actions, picks a range of numbers, such as -10 to +10, that are arbitrary at an overall level but reflect her relative preference for each action. It is then possible for the staff member to (consciously or unconsciously) do a cost-benefit analysis, identify highest net benefit, and consequently make her best choice.

The net benefit of the stairway is greater than the net benefit of the rear elevator. Therefore, the staff member rationally chooses the stairway.

Applying the framework:
- design elements → experience → choice → action → health
- stair → active living + views → climb stair → physical activity/improved mood

Patient scenario:
The patient must also choose between the lobby stairway and elevator. This person sees the stairway and the elevators for the first time. The patient takes the elevator, which is better for his health in his present state. Here is how a different rational choice may be made—as opposed to the standard understanding in the field of design and health without a model of agency.

- Patient evaluates climbing the stairway:
  - Benefits of climbing stairway = 4 units (e.g., reduced health benefit as he is unwell, etc.)
  - Costs of climbing stairway = 9 units (e.g., current condition, patient fall, etc.)
  - Net benefits = 4 – 9 = -5 units

- Patient evaluates riding the elevator:
  - Benefits of riding elevator = 5 units (e.g., patient safety, faster, less effort, assistance, conducive to patient state, etc.)
  - Costs of riding elevator = 2 units (e.g., walking to rear, multiple stops, etc.)
  - Net benefits = 5 – 2 = 3 units

The net benefit of the rear elevator is greater than the net benefit of the stairway. Therefore, the user rationally chooses the rear elevator, a different action.
Applying the framework:
- design elements → experience → choice → action → health
- elevator → no falls, safety → ride elevator → less risk, less stress

Assigning utility numbers: The patient also makes a list of actions and picks a range of numbers, such as -10 to +10, that are arbitrary at an overall level but reflect his relative preference for each action. The patient does a cost-benefit analysis for his best choice.

This is how rational decision-making works for different persons in the same situation, yielding different outcomes that are favorable to each person's well-being. Such rational choice is ubiquitous and can be used by designers for many settings.

Example 2: Behavioral choice—Add hallway or not
An existing senior home has to be renovated for healthy aging in place. The project team examines a resident's spontaneous daily choices using the behavioral method. The goal is to design choices in the home that are advantageous to the senior's aging in place.

Two options for the floor plan are considered: (a) living space connected by a hallway and (b) enlarged living space eliminating a separate hallway.

The scenarios are developed from the point of view of the resident's goals to improve his wellness by design. The design aims to enhance the user experience of the environment to induce desired actions. The example shows how behavioral choice and the status quo work.

Scenario one:

An existing floor plan has a hallway connected to a living space. The resident uses the hallway as an easy, attractive means to connect to the space. If asked, the resident claims he is active 40% of the time and is social 60% of the time. Hence, the resident's reference point that characterizes his existing situation is (active, social) = (40%, 60%). This is also called the status quo. Such reference points and contexts are always present in human decisions. In a number of commonly occurring situations, like the resident in this example, the reference situation makes all the difference.

Scenario two:

In time, the resident's family plans for him to age in place. They propose an environment to promote wellness at home with balanced physical, mental, and social activity. The plan allows for future home health care needs.

The new floor plan presents an option where the two spaces get combined into an enlarged open living space. This eliminates the hallway and enlarges the living space for multipurpose functioning and reduced need for physical mobility.

The design also enhances social uses with seating nooks, bookshelves, and artwork for interactions, alongside shorter movement paths, and is thus a gain for the user. But it would also eliminate the resident's hallway space and reduce his physical activity and so is a loss for him.

The resident must choose between the two options of (a) hallway and a living space and (b) no hallway and an enlarged living space.

In the second scenario, the resident would enjoy physical activity in another space only 20% of the time but increase being social within one enlarged space 80% of the time. In this situation the resident is (active, social) = (20%, 80%). The drop in physical activity in the enlarged room from 40% to 20% is a loss as measured from the resident's original reference point. Likewise, the increase in being social in the enlarged room, from 60% to 80%, is a perceived gain from the same reference point.

When a user evaluates the floor plan in each situation, he tries to see how his current situation would change relative to his existing situation. He does not compare scenario one with scenario two, the two absolute options before him, but assesses the relative differences between the two given his current reference points.


Hallway and living space


An enlarged single living space w/o hallway

In scenario two, the increased socialness in the enlarged room is a gain and the drop in physical activity is a loss relative to scenario one. If his gains and losses are assumed to be roughly equal, the gain could be represented as +50 and the loss could be represented as -50.

The graph below indicates that the value of a gain of +50 from the larger room is 65, shown by a large red dot at (50, 65) in the first quadrant. The value of a loss of -50 from physical inactivity is -90, shown by a large red dot at (-50, -90) in the third quadrant.

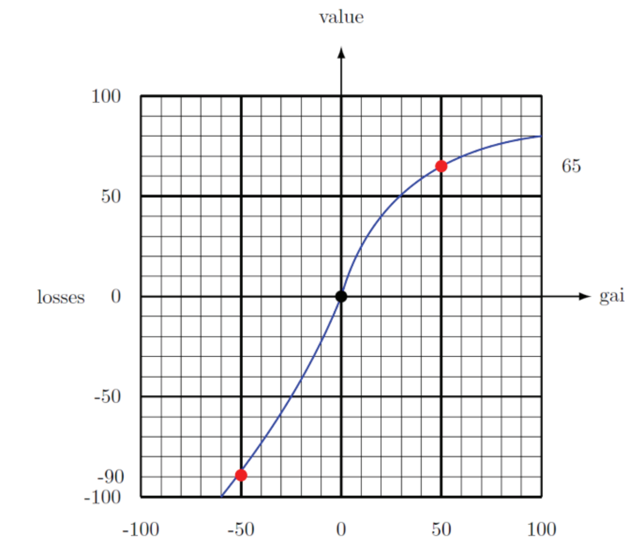
Thus, the value of a loss of 50 is -90 and is much greater than the value of a gain of 50, which is just 65. This is loss aversion, where a loss of a certain size looms larger (in value) than a gain of the same size.

Scenario two, an enlarged living space and no hallway, carries a positive value of 65 and a negative value of -90. Owing to loss aversion, the resident does not favor the second scenario plan and prefers the status quo.

Scenario one, the status quo with hallway and living room, can potentially be adapted to allow the resident to age in place, maintaining the health-promoting active days at 40%, and social activity at 60%.

Using the S-curve for analysis:
The S-curve is a tool that represents users' decision-making behavior. As Tversky and Kahneman showed graphically with the S-curve, a loss is felt more keenly than a gain. It uses two key concepts called reference point dependence and loss aversion—and can even predict user behavior. The shape of the curve (flatter with gains and steeper with losses) explains why the value of a loss is felt greater than the value of a similar gain. This tendency is called "loss aversion," and it means that people are averse to losses compared to gains.

The S-curve insight is that people value their gains and losses from a reference point (the status quo) and that losses are experienced as worse than equal gains. It shows how when the relevant gains and losses are roughly equal relative to a reference point, the losses will appear larger than the gains, and people will generally prefer the status quo. It allows prediction because people are assumed to choose what they prefer most among a set of alternatives.



For example, the graph shows gains from 0 to 100 and losses from 0 to -100 on the x-axis and the perceived value on the y-axis. The numbers—0 to -100 as losses and 0 to +100 as gains—are again somewhat arbitrary but capture the resident gains and losses experienced. The graph's proportions are based on the resident's (context-based) reference point and also matter. The current reference point of the user is at the origin (shown as a large black dot in the center), and his gains and losses are measured from the reference point. The value of the status quo choice is at zero, where the curve passes through the origin at the resident's reference point.

The graph represents the analysis that the value of a gain of +50 from the larger room is 65, shown by a red dot at (50, 65) in the first quadrant. The value of a loss of -50 from physical inactivity is -90, shown by a red dot at (-50, -90) in the third quadrant. The value of a loss of 50 is -90 and is greater than the value of a gain of 50, which is just 65. This is loss aversion, where a loss of a certain size looms larger (in value) than a gain of the same size.

We see how the experience of loss can lead people to choose the status quo, which is a preference for the existing condition.

In a status quo problem, there is an interesting further result. If the enlarged living space without a hallway, as in scenario two, had been the resident's reference point, and if he was considering a new design that adds a hallway and reduces the living space, as in scenario one, he would again prefer his status quo, which in this context is scenario two.

This time, the value of scenario two would exceed value of scenario one. Gains turn into losses and vice versa. In this reversed design scenario, there would be a less healthy physical activity outcome for the resident with scenario two = (20%, 80%) versus scenario one = (40%, 60%).

In other words, the status quo principle cannot be used blindly because in one direction it will improve health and in the other it will worsen health.

In terms of the framework, an architectural situation isn't "stable" and most often depends on the reference point, in addition to the choices it affords. This behavioral example has shown how subtle the problem of designing architectural choices for a home can be.

Status quo impact:
What does the status quo mean? In some situations, the status quo works to the user's advantage and in other cases to their disadvantage. It can be a useful concept that helps people hold their lives together near a reference point.

However, maintaining the status quo may determine that the outcome is disadvantageous. This is a truth and a challenge that practitioners deal with very often. Maintaining the status quo may not be in the best interest of a resident, or staff and patient. Using a Choice Architecture framework, can help designers overcome the significance of loss in the mind of a user.

In the status quo, where perceived losses are more powerful than perceived gains, this idea of loss aversion can be addressed using choice-based design. This framework has shown that built environment experiences impact user choices and actions to affect health. To detach from a reference point or status quo, designers should use their behavioral insight that it is the design of meaningful experiences that provide the key to how users reconcile choices with losses, gains and a reference point. Once separated from the status quo, given practical choices, the user converts easily to a different set of preferences. This could also suggest cost-effective solutions that the user would approve of as they would represent a pure gain with less loss.

Designers and owners can use this approach to drive innovation and further project goals based on understanding of how much of people's behavior is habitual and driven by cues in the environment. The approach provides a systematic way to predict human behavior to solve practical problems. It helps designers and owners determine when to depart from the "ideal" to offer users perceivable practical benefits.

The use of choice theory in influencing consumer behavior is not new in the design world. Product manufacturers have successfully used it to influence both rational and behavioral choices of customers in making purchase decisions. Incorporating such a theoretical framework in architectural decision-making means that the end product of a design process be presented like a consumer product having selective choice features that influence users toward making healthy choices.

Conclusion

What steps can or should be taken, then, to bring choice theory into mainstream design decision-making to create health-promoting experiences people feel better about converting to? Choice-based design has two major goals: to create enabling environments and experiences, and empower human choice and action toward health.

Among the key paradigm-changing concepts offered by Choice Architecture is the notion of "loss aversion" and "reference point." The extent to which the possibility that losses are perceived to have a greater weight than gains is considered in architectural decision-making is unknown. Similarly, the extent to which reference points are identified, examined rigorously, and defined in architectural decision-making is unknown. Incorporating these two concepts in decision-making could possibly narrow the gap between design intent and observed usage/behavior in significant ways. In essence, the fundamental discussion in the context of designing for health should be "behavior change"—from unhealthy to healthy, from risky to safe, from those invoking negative emotions to positive ones. The physical environment alone, or in conjunction with policies and programs, could be engineered to effect behavior change. Toward this end, Choice Architecture offers two starting points for architects and designers to consider—loss aversion and reference point. Once incorporated, other factors influencing behavioral choices could be systematically examined. Further incremental work remains until a robust information base can realize the true power of the framework, including in the domains of utility number scales and more detailed understanding of factors influencing behavioral choices in the designed environment.

Such details then should allow designers and owners to shape their projects' wellness outcomes with far greater precision than ever before.

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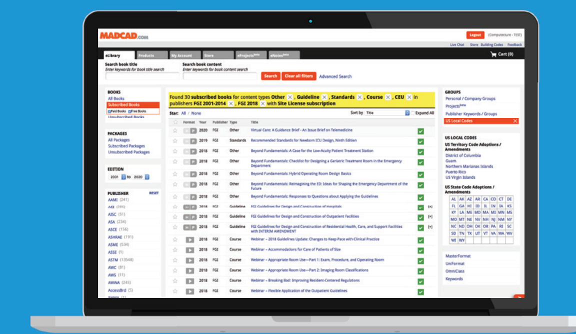

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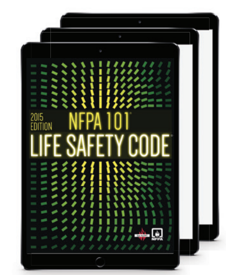

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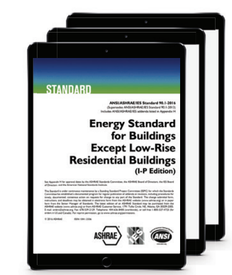

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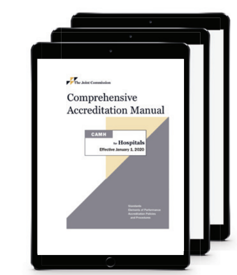

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