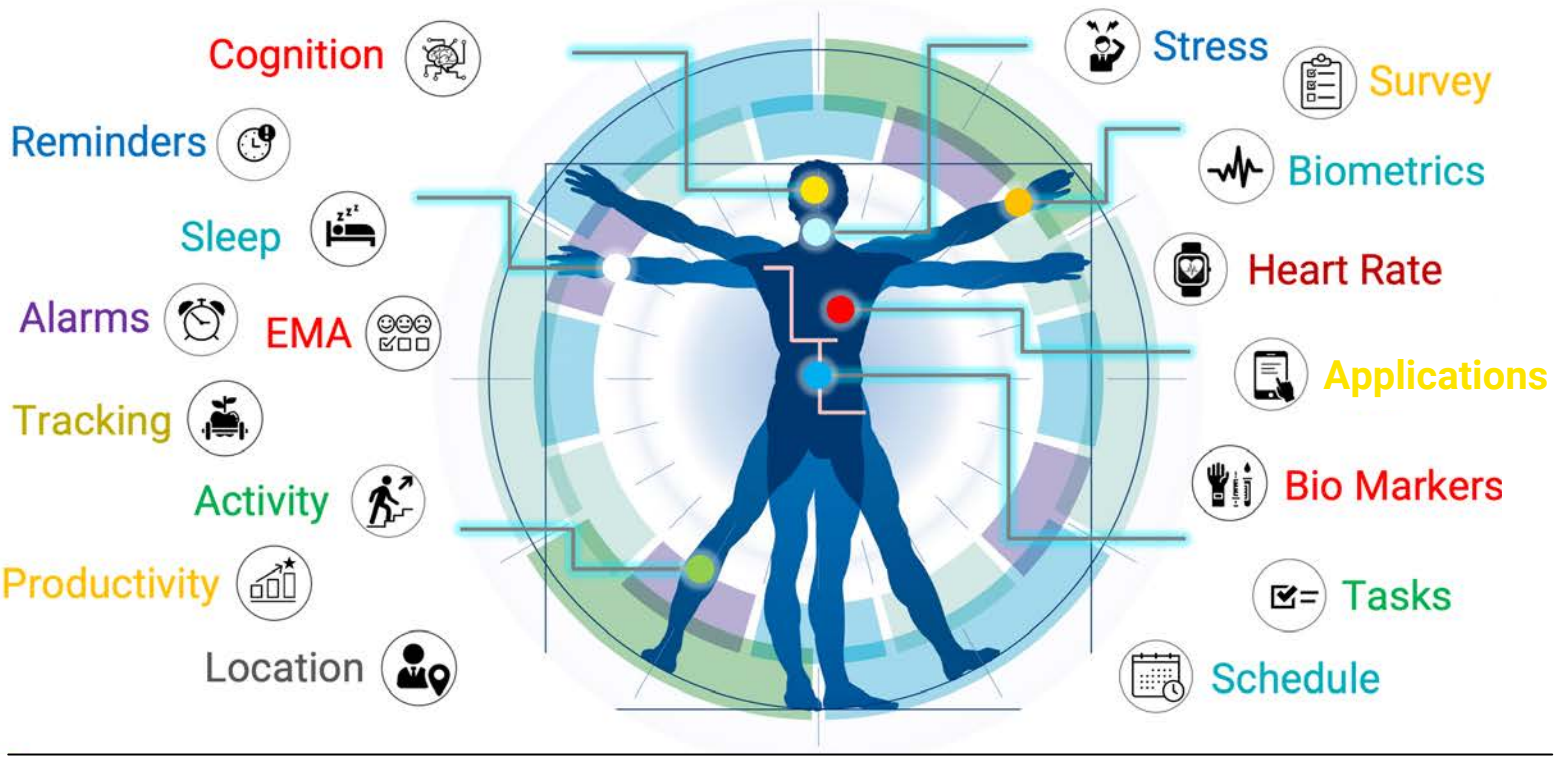
WELL LIVING LAB

annual report

2022



WELL LIVING LAB™

Healthy Living. Healthy Working. Healthy Aging.

Dear Colleagues,

We are pleased to share the 2022 Well Living Lab (WLL) Annual Report, highlighting the past year's accomplishments and our path ahead.

We are together on this journey of discovery in indoor health and well-being. You, our Scientific Advisory Council, Alliance members, and academic collaborators, are pioneers and innovators, shaping indoor health and well-being trends and inspiring our work.

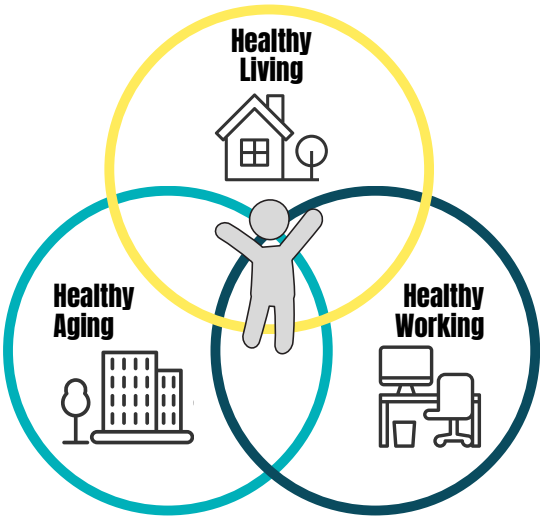
Over the past year, we have continued to expand our research beyond the walls of our Lab and into the places we live, work, learn, and play, such as offices, homes, and senior living facilities.

We celebrate the many ways we connect and collaborate to apply science-based solutions that enhance human health and well-being.

Cheers to the year ahead and our continued partnership!

Our Mission

Advance health and well-being through science-based solutions that improve how we live, work, learn, and play.



Sincerely,

Barbara Spurrier, M.H.A.
Executive Director, Well Living Lab; Executive Vice President, Delos

Bruce Johnson, Ph.D.
Research Director, Well Living Lab; Professor of Medicine & Physiology, Department of Cardiovascular Diseases, Mayo Clinic College of Medicine; Director of the Mayo Clinical Research Unit's Energy Balance Core Laboratory and the Human Integrative and Environmental Physiology Lab

Nick LaRusso, M.D.
Chair, Well Living Lab Scientific Advisory Council; Charles H. Weinman Professor of Medicine, Biochemistry and Molecular Biology; Distinguished Investigator of The Mayo Foundation

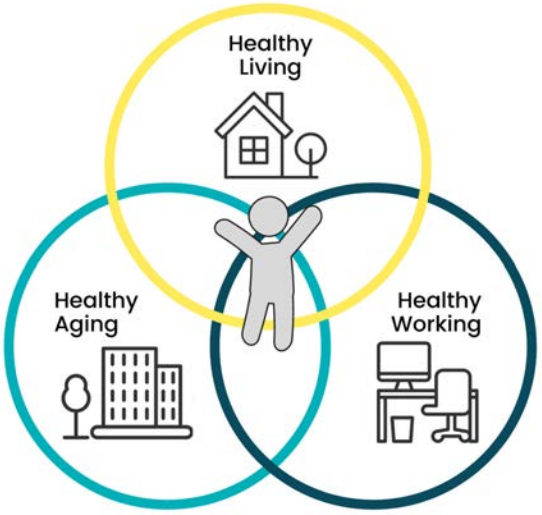
Table of Contents

Well Living Lab: By the Numbers

As of 12/31/2022

19 Multidisciplinary Team Members

3 Research Themes



29 Completed Research Studies **&** **27** Peer-Reviewed Publications

25 Well Living Lab Global Alliance Members

5500 Square Feet of Reconfigurable Space

4 Academic Collaborators

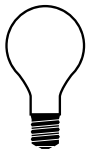
About the Lab

We spend about **90%** of our time indoors.

How much time do you spend indoors? For the average American, it's more than 21 hours a day, so it's critical that the indoor environments where we live, work, learn, and play positively contribute to our health, well-being, performance, and more.

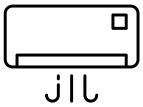
Why It Matters

Buildings and everything in them can affect our health and well-being. When we're healthy, we perform better in all aspects of life - as employees, employers, spouses or partners, parents, friends, and family members. Throughout our lifespan, indoor environments can affect our quality of life in many ways. As informed by Well Living Lab research, we have learned:



Lighting, temperature, and sound can impact sleep and cognitive function.

Natural lighting and biophilia can reduce stress and enhance mood, satisfaction, and productivity.



Automated, sensor-based filtration devices can significantly reduce exposure to harmful indoor air pollutants.

What We Do

The Well Living Lab is the first scientific research center exclusively applying human-centered research to understand the interaction between health, well-being, and indoor environments. Our real-world research spans healthy living, healthy working, and healthy aging.

The Lab, founded in 2016 as a collaboration of Delos and Mayo Clinic, is located in the Minnesota BioBusiness Center adjacent to the Mayo Clinic campus in downtown Rochester, Minnesota.

Our multidisciplinary research approach combines environmental, clinical, biomedical, and human behavior expertise with engineering and technology.

The Lab's unique, reconfigurable facility offers spaces to study residential, workplace, and classroom settings. It features advanced sensor technology and remote monitoring, allowing study participants to move freely, unencumbered by wires and monitors.

The need for more focused study of the connection between health and well-being and the indoor environment is real and immediate.

Strategic Goals

1. ADVANCE THE SCIENCE
2. ACCELERATE WITH TECHNOLOGY
3. CATALYZE INNOVATION
4. SHARE THE VOICE

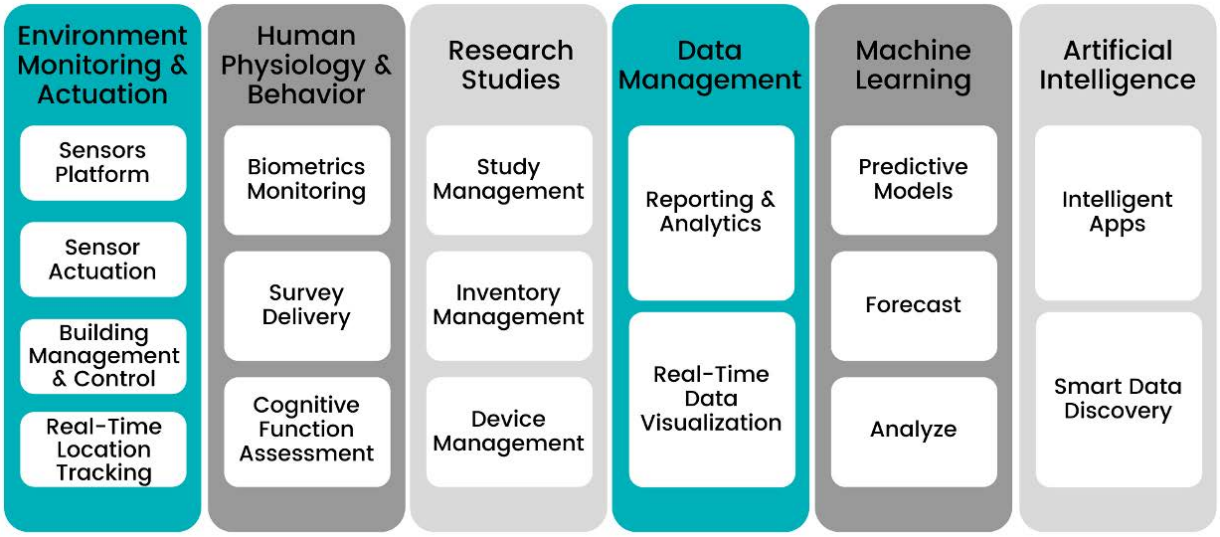
About the Lab (cont'd)

The only way to understand how
INDOOR ENVIRONMENTS
contribute to **HEALTH & WELL-BEING**
is to scientifically study them.

Research Approach

- Discovery > Translation > Application Framework
- Frequent coordination with Mayo Clinic research community and Institutional Review Board
- Single and multi-cohort studies with volunteer study participants
- Controlled in-lab studies and field studies
- Mixed methods approach, such as environmental sensors, wearable health sensors, and surveys, among other methods

Capabilities



Be Informed. Get Involved.

The movement to create healthy indoor spaces is growing rapidly as leaders from science, medicine, technology, architecture, real estate, and other industry recognize the connection between the indoor environment and health and well-being. Learn more about the Well Living Lab and become part of the movement.

delos™

The Well Living Lab is a subsidiary of Delos, a wellness real estate and technology company. Built on a ground-breaking collaboration between experts across the health sciences and building sciences, Delos helps transform indoor environments into vehicles for health, well-being, performance, and resilience.

Technology

Our state-of-the-art technology includes a flexible cloud infrastructure, data management system, and sensor integrations. These components have created a sophisticated technical platform, allowing us to carry out studies in the Lab and in the field.

2022 HIGHLIGHTS

- Acquired, on average, 600,000 data points from our sensors daily
- Eclipsed 2400 devices within the Lab (1100+ sensors, 1200+ actuators)
- Reached 2 TB of data accumulated across all our studies
- Developed a platform that allows new cognitive assessments to be developed in days versus weeks
- Deployed a new analytics tool enabling fast and practical data analysis for our scientists
- Improved Lab's overall network and infrastructure with enhanced data management and security
- Launched a new participant-facing application that integrates surveys, activity tracking, cognitive assessments, and more to deliver a seamless study experience
- Leveraged edge computing in our study platform to strengthen on-site capabilities and improve remote management for field studies

Collaboration

Collaboration has been key to the Lab's success since its launch in 2016.

Current academic collaborators include Mayo Clinic, the University of Minnesota, the University of Wisconsin, and the University of Groningen in the Netherlands. Discussions are underway with Arizona State University.

The Scientific Advisory Council and the Well Living Lab Alliance are the organizational ecosystems that connect academic and industry leaders with the Lab.

Well Living Lab Scientific Advisory Council

The Well Living Lab Scientific Advisory Council (SAC), in place since the Lab was established, includes ten prominent scientists and physician leaders from around the world. The SAC is chaired by an esteemed Mayo Clinic physician, scientist, and professor, Nicholas LaRusso, M.D.

The SAC met two times in 2022 to review the Lab's research roadmap and share guidance and thought leadership. Following these meetings, Well Living Lab's Executive Director, Barbara Spurrier, M.H.A., and Dr. LaRusso continue to work closely with the SAC and Lab team to ensure that the SAC recommendations are implemented in a manner that improves the Lab's scientific strategy and overall operation.

Well Living Lab Alliance

The Well Living Lab Alliance is a powerful cohort of global organizations aspiring to transform the places we live, work, learn, and play in a manner that improves health and well-being. With more than 20 leading organizations across a variety of industries - real estate, building, technology, design, housing, transportation, and more - each is committed to advancing science and generating evidence-based findings that can be practically applied for societal benefit.

Alliance membership is an impactful way for an organization to demonstrate its leadership, involvement, and commitment to indoor health and well-being. Benefits of membership include early access to study outcomes, opportunities to network and collaborate with the WLL team and other members, and member-only educational events, such as webinars and an Annual Summit.

Collaboration (cont'd)

Alliance Summit Recap

The 7th Annual WLL Alliance Summit was held in Rochester, Minnesota on October 4-5, 2022, with 34 individuals from 15 Alliance member organizations in attendance. The event included presentations by the Lab's scientists and technologists centered around the Lab's three themes: Healthy Aging, Healthy Working, and Healthy Living. Discussions among the WLL team and Alliance members generated new ideas for research and technologies as well as opportunities for collaboration.

Founding and Current Members

Hines
Panasonic
HARRISON STREET
MITSUBISHI ELECTRIC
Changes for the Better
IBM
3M
INTERNATIONAL WELL BUILDING INSTITUTE
GOLD MANTIS
essentia
STRUCTURETONE Southwest
CUSHMAN & WAKEFIELD
SINO-OCEAN 远洋地产
MARVIN
Milliken
HKS
Johnson Controls
Enterprise
RMZ CORP
noaber foundation
SHIMIZU CORPORATION
SHMZ
EMPIRE STATE REALTY TRUST
PARTICLEONE
SABRA HEALTH CARE REIT, INC.
Ford
kb HOME
h+k
WITHINGS
MASTER YOUR VITALS
kaiterra
hbreavis

About the Research

The Well Living Lab's long-term research objective is to improve human health and well-being across the lifespan. Our research plan sets the stage for achieving this objective by examining specific environmental interventions.

MISSION

Advance health and well-being through science-based solutions that improve how we live, work, learn, and play

CENTRAL QUESTION

What if the places we live, work, learn, and play improved health and well-being across the lifespan?

FRAMEWORK

Discovery

Translation

Application

PRIORITIES

DESIRABLE

Anchored around scientific exploration and human needs

VIABLE

Informed by assets and capabilities of Delos, Mayo Clinic, and partner organizations

POSSIBLE

Bolstered by technology

The Team

The Well Living Lab's multidisciplinary team consists of experts in biomedical engineering, building, behavioral, and data science, human physiology, technology, operations, communications, and more. By merging these diverse areas of expertise, we can conduct original, translational research that better addresses the complex interaction between health and the indoor environment.

Scientists

Sara Aristizabal, Ph.D., Research Scientist, Biomedical Engineering and Physiology

Dr. Aristizabal holds a Ph.D. degree in Biomedical Engineering and Physiology from the Mayo Clinic Graduate School of Biomedical Sciences. She has a keen interest in developing new techniques and biometric indicators to assess the health and wellness of the human body, specializing in signal processing, biological modeling, and clinical research. Her knowledge of the wearables research field helps us use the power of digital physiological signals to further understand the effect of the indoor environment on human health and well-being.

Kunjoon Byun, M.A., WELL AP, Senior Research Analyst, Behavioral Science

Mr. Byun earned his M.A. degree in Experimental Psychology from the College of William and Mary and a B.A. degree in Psychology from the University of Wisconsin – Madison. He assists in designing and executing research studies at the Well Living Lab and also participates in collecting and analyzing behavioral data. He has research experience in various fields of psychology with an emphasis on judgments and the decision-making process.

Robert Klein, Ph.D., Research Scientist, Well-Being and Personality Psychology

Dr. Klein earned his M.S. and Ph.D. in Social Psychology at North Dakota State University, where he developed new methods for assessing dynamic emotion reactivity and sought to uncover links between emotion dynamics and psychological well-being outcomes. Dr. Klein also worked with expert meditation teachers to develop and validate a new cognitive mindfulness intervention. He completed an NIH-supported postdoctoral fellowship at Dartmouth College's Geisel School of Medicine, where he conducted studies examining dysregulated emotion as a transdiagnostic risk factor in the development of depressive, anxiety, and substance use disorders.

Meng Kong, Ph.D., Research Scientist, Building Science, Mechanical & Aerospace Engineering

Dr. Kong has more than ten years of research experience in built environmental and energy systems. He earned his Ph.D. in Mechanical and Aerospace Engineering from Syracuse University, where he then worked as a postdoc and research assistant professor for two years. Dr. Kong's Ph.D. work focused on developing a micro-environmental control system for improving thermal comfort, indoor air quality, and building energy efficiency. He has led research projects on indoor and outdoor air quality control, including the airborne transmission of SARS-CoV-2.

Scientists (cont'd)

Linhao Li, M.S., R&D Technical Manager; Senior Research Analyst, Building Science

Mr. Li received his M.S. of Architecture degree from Carnegie Mellon University. He holds a B.S. degree in Built Environment and Facilities Engineering from Tongji University in China. He supports the design and execution of research studies, contributes to our understanding of the interactions between building environments and human health, wellness, and performance, and is proficient in a variety of computational simulation tools.

Jovan Pantelic, Ph.D., Research Scientist, Building Science, Mechanical Engineering

Dr. Pantelic earned his Bachelor of Mechanical Engineering and his M.S. from the Department of Thermal Engineering at the University of Belgrade (Serbia). He earned his Ph.D. from the National University of Singapore where he studied in the School of Design and Environment, Department of Building. He has spent the last 17 years researching indoor air quality. His research on air spans from the airborne spread of infectious diseases in the built environment to the impact of large-scale episodic pollution events, such as wildfires. Dr. Pantelic has worked on Internet of Things (IoT) sensing and is considered a leading expert in the field.

Zachary Pope, Ph.D., Research Scientist & Team Lead, Physiology & Behavioral Science

Dr. Pope, a physiologist with expertise in behavioral science, was a National Heart, Lung, and Blood Institute T32 Postdoctoral Fellow in the University of Minnesota's School of Public Health, Division of Epidemiology and Community Health. He earned his Ph.D. in kinesiology, with a minor in public health, at the University of Minnesota. His master's and undergraduate degrees are from Boise State University, where he studied exercise physiology. Dr. Pope is skilled in the assessment of cardiometabolic, physiological, and psychological health outcomes as well as clinical trial design and implementation.

Young Joo Son, Ph.D., Research Scientist, Building Science, Architecture & Building Performance

Dr. Son earned her B.S. and M.S. in Interior Architecture and Built Environment from Yonsei University in South Korea and her Ph.D. in Building Performance and Diagnostics from Carnegie Mellon University. Her prior research experience identified the impact of indoor environmental quality on occupant satisfaction and comfort, focusing on thermal and lighting environments. She designed and conducted human subject experiments in laboratory and field settings and collected human physiological and psychological responses.

Technologists

Chi Lam, M.S., Director of Technology

Mr. Lam has more than 20 years of technology and leadership experience and focuses on technology's role as a strategic enabler for business. He earned both an M.S. degree in electrical engineering and computer science and a B.S. degree in electrical engineering from the University of Illinois in Chicago. Lam works with the lab to determine overall information technology (IT) strategies, tasks, and prioritization and provides direction to IT staff to ensure that goals and objectives are met. He also focuses on bringing cutting-edge technology to the lab for research endeavors.

Jeremiah Carlin, B.S.C.S., Senior Developer Full-Stack Software Engineer

Mr. Carlin has over 15 years of development expertise in a wide variety of fields and technologies, including mobile, backed-end services, systems management, and firmware. He earned a B.S. in computer science from Michigan Tech before taking a position at IBM in Rochester Minnesota. In his time at IBM, Carlin developed kernel code for IBM's i Series operating system, wrote firmware for a cell-based graphics card, and created applications to manage virtualized systems. He also helped design a cellular network data optimization appliance and ran the development lab for IBM Watson's healthcare division.

Jeremiah Harbach, B.A., Software Engineer

Mr. Harbach brings over ten years of IT experience to the Well Living Lab. He worked on Google's corporate operations engineering team in Mountain View, CA. In 2019, he joined the medical device startup Sonex Health to lead its IT department. While at Sonex, Harbach deployed several custom software solutions, including a self-service ultrasound training portal as well as the UltraGuide VTP telesimulation platform, and helped design Sonex Health's state-of-the-art educational institute. He holds a B.A. in Interdisciplinary Studies: Organizational Leadership from Wisconsin Lutheran College.

Brant Staven, B.A., Senior Internet of Things (IoT) Engineer

Mr. Staven offers 20 years of information technology experience, including front-end and back-end programming, web development, and cloud applications. He applies his interests in the Internet of Things, wireless sensors and actuators, internet-capable systems-on-a-chip, big data, and cloud computing. He holds a B.A. in Computer Science from Luther College and helped develop software for Best Buy and Accenture Technology Solutions before joining Mayo Clinic's Emergency Department to design and develop a Health Insurance Portability and Accountability Act (HIPAA) compliant, real-time multi-patient situational awareness dashboard for patient flow.

Administration

Barbara Spurrier, M.H.A., Executive Director, Well Living Lab & Executive Vice President, Delos

Ms. Spurrier provides leadership and strategic direction to the Well Living Lab. Prior to joining the Lab, she served as administrative director of Mayo Clinic Center for Innovation (CFI), building the center from the ground up. CFI's mission was to transform the delivery and experience of health and health care and advance a competency of innovation across Mayo Clinic. She has been active with the University of Minnesota, serving as a preceptor for students, a member of the MHA Alumni Board, and participating as a guest lecturer in the business school. She holds a B.A. degree in Economics and a master's in Health Care Administration (M.H.A.) from the University of Minnesota.

Nicholas F. LaRusso, M.D., Chair, Well Living Lab Scientific Advisory Council & Professor of Medicine, Consultant, Mayo Clinic

Nicholas F. LaRusso, M.D., is the Charles H. Weinman Endowed Professor of Medicine, the former Medical Director of the Mayo Clinic Center for Innovation and Mayo Clinic Center for Connected Care, and a Distinguished Investigator of the Mayo Foundation. He has also held positions as Vice Chair for Research of the Department of Medicine (DOM), Chair of the Division of Gastroenterology and Hepatology, and Chair of the DOM, all at Mayo Clinic. Dr. LaRusso received his undergraduate degree from Boston College, his M.D. from New York Medical College, and his training in internal medicine and gastroenterology at Mayo. He has received multiple awards and recognitions and was ranked in the top 1% of physicians in the country by US News and World Report.

Bruce Johnson, Ph.D., Research Director, Well Living Lab & Professor of Medicine, Consultant, Mayo Clinic

Bruce Johnson, Ph.D., is a Professor of Medicine and Physiology and a Consultant in the Department of Cardiovascular Diseases. He has joint appointments in Preventive, Occupational, and Aerospace Medicine as well as in the Department of Physiology and Biomedical Engineering. He is the Director of the Mayo Clinical Research Unit's Energy Balance Core Laboratory and directs his own research laboratory in human integrative and environmental physiology. The majority of his research has focused on factors limiting human performance in various clinical syndromes, in athletes, and under extreme environmental conditions. His clinical research focuses on novel methods for detection and tracking chronic disease as well as environmental factors that may be involved in disease risk. The NIH, DOD, NSF, State of Minnesota, and Industry have funded his work.

Administration (cont'd)

Eric Heins, B.A., P.M.P., Director of Operations

Mr. Heins has experience in accounting, project management, supplier relations, and contract management, and is responsible for developing and managing Well Living Lab budgets and procurements. He also assists with the project management needs of the lab. Heins holds a project management professional (P.M.P.) certification and has a B.A. in Accounting from the Minnesota School of Business. Before joining the lab, he worked for 11 years at Mayo Clinic, as an accountant, IT systems analyst, and project analyst, working in finance, administration, and IT.

Elizabeth Karsell, B.A., Executive Assistant

Ms. Karsell provides organizational support to help ensure more efficient team operations. Before joining the Well Living Lab, her professional roles included: Administrative Director of The Rotary Club of Rochester, supporting the organization in its efforts to promote personal and professional integrity, assist fellow community members in need, and advance understanding and peace throughout the world; Paraprofessional and Media Paraprofessional in the Rochester and Glencoe - Silver Lake Public School districts; and Chamber of Commerce Executive Director and part-time Economic Development Director for the city of Glencoe, Minnesota, facilitating new business and growth of existing business through economic incentives, strategic collaborations, and community events. Karsell holds a B.A. in Religion from St. Olaf College.

Sarah Oslund, M.A., Director of Communications and Marketing

Ms. Oslund serves as the Well Living Lab's communications and marketing director, bringing more than 16 years of experience to her role. She has led communications, marketing, and public relations-related efforts for the University of Minnesota Rochester, Lakeville Area Public School District, Zumbro Valley Health Center, and the City of Rochester. She possesses a wide breadth of communications experience in areas ranging from strategic crisis communications to maximizing social media engagement to effective storytelling. Oslund holds a B.S. in Psychology from Minnesota State University Mankato and a M.A. in Management from St. Mary's University of Minnesota.

2022 Peer-Reviewed Publications

Peer review is critical as a quality control measure for scientific articles. The process involves having other experts in the same field check the validity of a paper, ensuring the integrity of the science. The Well Living Lab would like to see its studies not only published in peer-reviewed scientific journals but also translated into real-world practices to promote healthy environments across an individual's lifespan.

LEARN MORE

1. Transformational Internet of Things (IoT) Sensing for Air Pollution and Thermal Exposures, Frontiers in Built Environment.
2. Bridging the Gap from Test Rooms to Field-tests for Human Indoor Comfort Studies: A Critical Review of the Sustainability Potential of Living Laboratories, Energy Research & Social Science.
3. Effect of Low-Cost Recirculating Air Filtration on Aerosol Particle Deposition and Concentration in a Conference Room: Experiment, Theory, and Simulation Comparison, Journal of Aerosol Science.
4. Investigating How Auditory and Visual Stimuli Promote Recovery After Stress With Potential Applications for Workplace Stress and Burnout: Protocol for a Randomized Trial, Frontiers in Psychology.
5. Study on the Evolution Characteristics of Temperature and Heat Storage of the Soil Surrounding the Tunnel with Years, Energy and Buildings.
6. Localized and Whole-Room Effects of Portable Air Filtration Units on Aerosol Particle Deposition and Concentration in a Classroom Environment, American Chemical Society (ACS) ES&T Engineering.
7. Development of a Testing and Evaluation Protocol for Occupancy Sensing Technologies in Building HVAC Controls: A Case Study of Representative People Counting Sensors, Building and Environment.
8. Inactivation of Replication-Competent Vesicular Stomatitis Virus as SARS-CoV-2 Surrogate on Common Surfaces by Disinfectants, International Journal of Environmental Research and Public Health.
9. Healthy Home Interventions: Distribution of PM2.5 Emitted during Cooking in Residential Settings, Building and Environment.
10. HVAC energy savings, thermal comfort and air quality for occupant-centric control through a side-by-side experimental study, Applied Energy.

Completed Studies

2016

ENVIRONMENTAL COMFORT (OFFICE)

2017

DAYLIGHT-COGNITIVE FUNCTION (OFFICE)
BLUE ENRICHED LED SLEEP (OFFICE)
HIGH STRESS MEASUREMENTS (PILOT)
SCENT DIFFUSION IAQ (PILOT)

2018

DYNAMIC LIGHTING (OFFICE)
SLEEP MICROCLIMATE (RESIDENTIAL)

2019

COGNITIVE FUNCTION IN CONSTRUCTION (FIELD)
COGNITIVE FUNCTION DURING HYPOXIA (FIELD)
BIOPHILIC OFFICE DESIGN (OFFICE)
AUTOMATED WAKE-UP (RESIDENTIAL)
MOBILE ENVIRONMENTAL SENSOR DEPLOYMENT (FIELD)

2020

OCCUPANCY SENSOR TESTING (OFFICE)
ARPA-E (OFFICE)
SURFACE: VSV DISINFECTION (COVID)

2021

AIR: CONFERENCE ROOM AIR PURIFICATION (COVID)
AIR: OFFICE SPACE TRANSMISSION (COVID)
AIR: CLASSROOM AIR PURIFICATION (COVID)
SURFACE: SARS-COV-2 DISINFECTION (COVID)
BEHAVIOR: CAPTURE SURVEY BASELINE (COVID)
RESIDENTIAL INDOOR AIR FILTRATION EXPERIMENT (LAB)

2022 Completed Studies

The Well Living Lab has made significant advancements in its human-centered scientific approach to best investigate the impacts of indoor air quality, lighting, biophilia, and other exposures on cognitive performance, sleep quality, stress, and multiple other health outcomes (e.g., heart rate variability, blood pressure, neural activity, biomarkers). On the pages that follow, you will find overviews of our 2022 completed studies.

Residential Indoor Air Quality

What We Studied

We studied how indoor air pollution affects physiological and psychosocial outcomes and whether automating ventilation and filtration systems to better control indoor air pollutant concentrations, particularly while individuals cook and clean, may lead to improved health versus manual control of these systems.

Why It Matters

The Environmental Protection Agency has noted that exposure to indoor air pollutants is significant and can negatively impact health [1]. The primary source of residential indoor air pollution is cooking, which typically takes place throughout the average day. It is important to a) explore advanced technologies that can ensure air is adequately filtered around the time of this activity and b) understand the effectiveness of solutions as both stand-alone and as a system.

High Level Findings

Results showed that an automated indoor air quality (IAQ) control intervention that coordinated the function of a stove hood, portable air filtration units, and a bathroom exhaust fan based on real-time sensor readings of particulate matter 2.5 (PM2.5) reduced exposure to PM2.5 by ~35% relative to a standard control condition during which participants manually controlled the stove hood and bathroom exhaust. Results also suggested slightly better physiological outcomes (e.g., systolic blood pressure, fractional exhaled nitric oxide (FeNO), and some aspects of heart rate variability metrics) during the automated IAQ control intervention relative to the standard control condition, with no differences in participant perception of IAQ between these conditions.

Lead Scientist: Jovan Pantelic, Ph.D.
Collaborator: *Confidential*
Study Location: Lab
Research Theme: Healthy Living

[1] EPA. (2022). https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality

COVID-19 and Beyond: Safe Indoor Environment Program CAPTURE Survey

What We Studied

We studied how to reduce airborne- and surface-based transmission of respiratory viruses and examined employee well-being during the COVID-19 pandemic. One of the six COVID program studies was the CAPTURE Survey. This one-year longitudinal survey of up to 3600 non-healthcare employees assessed changes in select psychological outcomes, health behaviors, and COVID-19-related transmission prevention behaviors and perceptions.

Why It Matters

Since March 2020, COVID-19 has infected >600 million individuals and led to >6 million deaths worldwide [1]. Evaluating advanced technologies and strategies that limit air- and surface-based disease spread, as well as investigating the health and well-being of workforce sectors impacted by the COVID-19 pandemic, is critical now - during the pandemic - and for future seasonal disease outbreaks (such as influenza).

Lead Scientist: Araliya Senerat, M.P.H., P.M.P.
Collaborator: University of Minnesota & Mayo Clinic
Study Location: Field
Research Theme: Healthy Working

High Level Findings

Relative to pre-pandemic, poorer psychological outcomes (e.g., higher stress and anxiety) and worsened health behaviors (e.g., lower physical activity and sleep durations; higher non-work screen time) were observed across all survey time points, with values worst at the baseline and 12-month time points when COVID-19 surges were highest.

While COVID-19 prevention behaviors (e.g., mask wear, physical distancing) were consistently deemed to be important and adhered to by employees, the psychological and health outcome data suggest the potential for harmful long-term effects of the pandemic on the well-being of non-healthcare employees and the need for employee well-being programs.

[1] WHO Coronavirus (COVID-19). (2023). https://covid19.who.int/

Acute Stress Recovery: Pilot Study

What We Studied

We studied how visual and/or auditory features of a relaxation room can positively impact recovery from stress.

Why It Matters

According to the 2021 Stress in America™ survey, work-related stress is the top stressor among adult workers [1]. Relaxation rooms are one organizational strategy being used to reduce workplace stress. However, it is not well understood how the way a person perceives stress relates to the body's physical responses to stress. Understanding how physiological stress responses relate to improvements in perceived stress when using a relaxation room could lead to more effective strategies in addressing workplace stress.

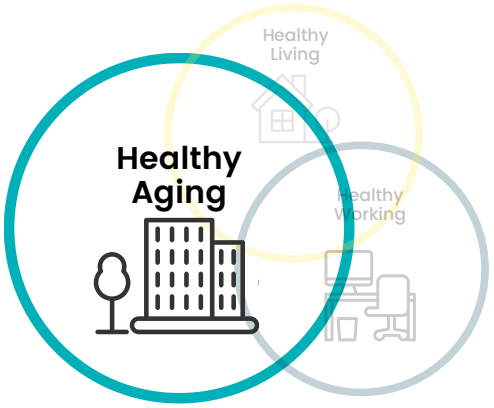
High Level Findings

Across Pilot Study participants, numerous physiological measures changed when experiencing an acutely stressful event. Heart rate and select measures of neural activity significantly increased during this event, whereas heart rate variability decreased.

Lead Scientist: Kevin Mazurek, Ph.D.
Collaborator: Delos
Study Location: Lab
Research Theme: Healthy Working

Additionally, individuals' perceptions of their own stress and anxiety increased during this event. Each of these measures subsequently recovered to their pre-stress levels when experiencing the visual and auditory stimuli of the relaxation room. Interestingly, cognitive performance was unaffected by stress. Heart rate and select measures of heart rate variability and neural activity significantly correlated with participants' stress perceptions. Observations suggest certain physiological measures may better indicate an acute stress response than others—important when developing interventions to mitigate workplace stress. The larger Acute Stress Recovery Main Study recently finished data collection, with forthcoming results expected to help provide further clarity on these Pilot Study results.

[1] American Psychological Association. (2021). https://www.apa.org/news/press/releases/stress/2021/october-decision-making



Portable Air Filtration in a Skilled Nursing Facility

What We Studied

We studied whether technologies, such as portable air filtration units, aimed at improving indoor air quality can reduce how many particles are present in the air and on surfaces in a skilled nursing facility. This is critical in limiting respiratory virus transmission and improving health and well-being among older adults.

Why It Matters

In the U.S., COVID-19 has led to >1 million confirmed cases and 160,000 deaths among residents in nursing homes as of December 2022 [1]. Compared with younger age groups, older adults are more prone to mortality following COVID-19 [2] or other respiratory infections [3] due to the prevalence of high comorbidity (such as heart disease or diabetes). To mitigate respiratory infection risk in skilled nursing facilities, it is critical to reduce potentially-infectious particles in the air and on surfaces [4] to minimize exposure and lower the spread of infection [5-7].

High Level Findings

Portable air filtration units resulted in air exchange rates (the number of times the total volume of air in a room is completely removed) that were 4x more efficient within the skilled nursing facility. This resulted in up to 7x lower particle concentration in the air, and 7x lower particle accumulation on surfaces. Observations indicate that portable air filtration units may help reduce disease transmission in similarly-sized spaces such as offices, conference rooms, hotel lobbies, classrooms, and apartments.

Lead Scientist: Linhao Li, M.S.
Collaborator: Sabra
Study Location: Field
Research Theme: Healthy Aging

[1] Center for Medicare and Medicaid Services. COVID-19 Nursing Home Data. https://data.cms.gov/covid-19/covid-19-nursing-home-data.
[2] Centers for Disease Control and Prevention. COVID Data Tracker. https://covid.cdc.gov/covid-data-tracker/#demographicsovertime.
[3] Centers for Disease Control and Prevention. Influenza (Flu). https://www.cdc.gov/flu/about/burden/2019-2020.html.
[4] Offerman et al. (1985). https://doi.org/10.1016/0004-6981(85)90003-4.
[5] Chen et al. (2010). https://doi.org/10.1098/rsif.2009.0516.
[6] Miller-Leiden et al. (1996). https://doi.org/10.1080/10473289.1996.10467523.
[7] Zuraimi et al. (2011). https://doi.org/10.1016/j.buildenv.2011.06.008.

Clinician Burnout: Pilot Study

What We Studied

We studied whether relaxation rooms effectively reduce burnout and workplace stress while improving job satisfaction for Mayo Clinic clinicians.

Why It Matters

Burnout is significantly more likely for physicians compared to the general working population in the United States [1]. Physician burnout has adverse consequences on the quality and safety of patient care. Additionally, a 2019 analysis estimated that physician turnover and reduced clinical hours due to burnout costs the U.S. $4.6 billion dollars annually [2]. Determining whether relaxation rooms are effective at mitigating the adverse effects of burnout and workplace stress could provide healthcare organizations with more impactful interventions that benefit employee health and well-being.

High Level Findings

Most clinicians who used the relaxation room reported "substantial" or "somewhat" reduced perceptions of work stress. Further, most clinicians reported that the provision of the relaxation room "substantially" or "somewhat" increased their overall job satisfaction at Mayo Clinic. The Clinician Burnout Main Study began in Q1 2023. As the Main Study is explicitly focused on the subset of physicians, results from the Main Study are expected to yield insight into how relaxation room use impacts physicians' stress and burnout, among other outcomes.

Lead Scientist: Kevin Mazurek, Ph.D.
Collaborator: Mayo Clinic
Study Location: Field
Research Theme: Healthy Working

[1] Shanafelt et al. (2019). https://doi.org/10.1016/j.mayocp.2018.10.023.
[2] Han et al. (2019). https://doi.org/10.7326/M18-1422.

2023 Priorities

The path ahead for the Well Living Lab is an exciting one, with multiple studies on the horizon.

Well Living Lab Test Home: A Marvin Collaboration

The Well Living Lab Test Home: A Marvin Collaboration is anticipated to open later this year in the heart of the Destination Medical Center (DMC)—a robust 20-year, $5.6 billion economic development initiative, the largest in Minnesota's history. The DMC is designed to position Minnesota as a global center for the highest quality medical care and to generate high-value jobs, new tax revenue, and businesses.

The Well Living Lab Test Home will examine how real-world integration of smart home Internet of Things (IoT), digital health sensors, and other advanced technologies can support healthy living in pre-retirement populations. Well Living Lab scientists will conduct high-impact research that investigates how first-of-their-kind indoor environmental interventions impact multiple health outcomes.

Why It Matters

Smart home technology can enable middle-aged and older adults to understand and manage their health at home. Indeed, quality home controls can be developed and tailored to an individual's lifestyle to improve sleep quality, work performance, and satisfaction. It is thus critical to understand the preferences and behaviors of occupants as they use smart, personalized home controls to best develop and implement interventions that have the greatest beneficial impact on health and well-being.

Lead Scientist: Young Joo Son, Ph.D.
Collaborator: Marvin
Study Location: Field
Research Themes: Healthy Living & Healthy Aging

Indoor Air Quality, Energy Consumption, & Office Worker Performance

The Indoor Air Quality, Energy Consumption, & Office Worker Performance Study will study how improved ventilation and filtration interventions in an office may improve indoor air quality (IAQ) and employee performance and health, with a positive financial outcome for the company when compared to traditional ventilation and filtration.

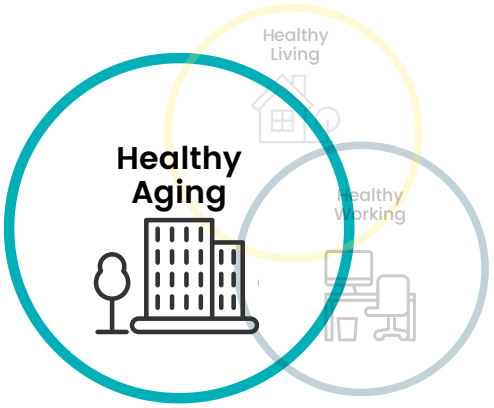
Why It Matters

Companies spend around 100 times more on personnel costs than utilities [1]. IAQ in offices is among the most important factors potentially affecting the overall environmental quality and cognitive function of employees [2], which ultimately impacts their ability to be productive and contribute to a company's bottom line.

Lead Scientist: Meng Kong, Ph.D.
Collaborator: Johnson Controls International
Study Locations: Lab & Field
Research Theme: Healthy Working

Indeed, an economic and environmental analysis of enhanced ventilation in office buildings across seven different U.S. climate zones showed that doubling the ventilation rate costs less than $40 per employee per year. The same change in ventilation improved the performance of workers by 8%, equivalent to a $6500 increase in employee productivity each year [3].

[1] JLL. (2016). https://www.jll.ca/en/trends-and-insights/workplace/a-surprising-way-to-cut-real-estate-costs.
[2] Wei, wt al. (2020). https://doi.org/10.1016/j.enbuild.2019.109683
[3] MacNaughton, et al. (2015). https://www.mdpi.com/1660-4601/12/11/14709



Indoor Lighting and the Brain and Cognitive Health in Older Adults

The Indoor Lighting and the Brain and Cognitive Health in Older Adults Study will examine whether the quality of indoor lighting can improve measures of brain and cognitive health in older adults.

Why It Matters

The population aged 60 years and older will double from 1 billion in 2019 to 2.1 billion in 2050 [1]. Certain lifestyle behaviors can help people manage their health and quality of life as they age, thus facilitating the ability to live more independently.

Staying mentally, physically, and socially active and engaging in proper sleep habits can potentially slow memory decline and lower the risk of developing Alzheimer's disease or other dementias [2]. Improved indoor lighting may help promote these lifestyle behaviors and improve the outcomes of aging.

Lead Scientist: Robert Klein, Ph.D.
Collaborator: Harrison Street
Study Location: Field
Research Theme: Healthy Aging

[1] Pekkarinen, et all. (2004). https://academic.oup.com/gerontologist/article/44/5/633/798707?login=false
[2] Mayo Clinic Health System. (2022). https://www.mayoclinichealthsystem.org/hometown-health/speaking-of-health/5-tips-to-keep-your-brain-healthy

Clinician Burnout: Main Study

The Clinician Burnout Main Study will expand upon the Pilot Study (reviewed on page 23) to investigate whether relaxation rooms effectively reduce burnout and workplace stress, while improving job satisfaction, for Mayo Clinic physicians.

Why It Matters

While burnout is prevalent among many clinician categories, physicians have among the highest burnout rates in the United States [1]. Physician burnout has negative consequences on patient care as well as the medical economy at-large [2]. Thus, relaxation rooms may be an organizational approach that can be taken to reduce workplace stress that precipitates burnout. Our Pilot Study results among Mayo Clinic clinicians suggested that a relaxation room may lead to reduced workplace stress and increased satisfaction. We believe that an intervention specifically targeting the subset of Mayo Clinic physicians may yield even stronger results.

Lead Scientist: Kunjoon Byun, M.A.
Collaborator: Mayo Clinic
Study Location: Field
Research Theme: Healthy Working

[1] Shanafelt et al. (2019). https://doi.org/10.1016/j.mayocp.2018.10.023.
[2] Han et al. (2019). https://doi.org/10.7326/M18-1422.

Nursing Team Multisensory Stress Reduction in a Skilled Nursing Facility

The Nurse Stress Reduction in a Skilled Nursing Facility Study will explore whether exposure to a combined mindfulness-based smartphone app and biophilic intervention might reduce stress, burnout, and fatigue in nurses, benefiting their health and well-being and the quality of care provided to residents.

Why It Matters

Nursing is among the most stressful professions in healthcare [1], with up to one-half of nurses reporting a feeling of professional burnout. Nurses in skilled nursing facilities face particularly high rates of stress, burnout, and fatigue. Combining a nature-based mindfulness and relaxation smartphone app with biophilic intervention might reduce this population's stress, burnout, and fatigue.

Lead Scientist: Zachary Pope, Ph.D.
Collaborator: Sabra
Study Location: Field
Research Theme: Healthy Working

[1] WHO Aging Statistics. https://www.who.int/health-topics/ageing#tab=tab_1

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