UNIVERSITY OF WISCONSIN–MADISON
COLLEGE OF ENGINEERING

FALL 2021 NEWSLETTER

INDUSTRIAL & SYSTEMS ENGINEERING

DATA FOR THE GREATER GOOD

New leadership, continued growth in data science

Greetings From Madison!

Twelve months ago, we were adapting to a 100% virtual experience for all university operations. One year later, we have proven that no matter the format, we can continue to be a leader in higher education. In September we began a new academic year with an intentional plan for a physical return to campus, but also with the experience and know-how to adapt as needed. No matter what challenges we face in the coming year, we are certainly positioned to succeed.

Our research proved especially relevant over the past year, as we were frequently called upon to apply our expertise in efforts to fight the pandemic. From supplying PPE to areas in need, to modeling disease progression, our faculty and grad students rose to the challenge. As a department, we've been extremely grateful for the opportunity to contribute to the greater good in this important way.

Our students and faculty racked up an impressive number of awards over the last several months. Collectively, our department has been honored with numerous scholarships, grants, fellowships and more. I'm proud to lead such a bright and ambitious group of individuals!

The past few months have seen some changes to our roster of world-class faculty. Longtime faculty member Pascale Carayon retired from formal faculty duties but will continue to make contributions to the field of healthcare systems engineering. We are proud to welcome Qiaomin Xie as our latest assistant professor. Qiaomin comes to us from Cornell University, with a focus on research that combines mathematical modeling and data science to improve complex systems. And finally, we say thank you—but not goodbye—to Professor Jeff Linderoth, who served as our department chair for the last five years. Jeff will take a well-earned sabbatical and then return to his passion for teaching and research in our department.

As a department, we continue to evaluate our core values and mission, welcome students from all social classes, offer our students a world-class educational experience, and pursue research for the greater good.

We are grateful for your continued support of our department. If you find your way to campus this fall, we'd love to have you stop by and visit us in person. Until then, please feel free to reach out by phone or email.

On, Wisconsin!

Laura Albert

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Analysis reveals COVID-19's impact on breast cancer outcomes

The spread of COVID-19 in spring 2020 consumed the United States' healthcare system, shelving seemingly less-pressing medical concerns. Hospitals, clinics and patients alike postponed elective procedures and routine appointments.

But even sensible precautions have knock-on effects: Delayed or missed care can mean diseases go undetected and untreated.

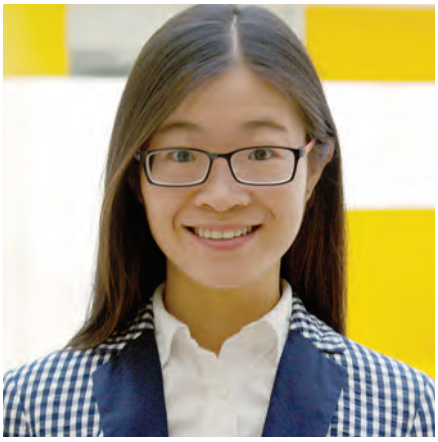
With that in mind, a group of researchers led by Proctor and Gamble-Bascom Professor Oguzhan Alagoz analyzed the impact of COVID-enforced disruptions to preventative care on long-term breast cancer mortality.

The researchers, who published their findings in a paper in the *Journal of the National Cancer Institute*, discovered the effect was, thankfully, small. Their collaborative modeling study estimates that by 2030, 2,487 additional breast cancer deaths will occur due to the pandemic's interruption of mammography screenings, symptomatic diagnoses and chemotherapy treatments. In all, that amounts to slightly greater than a half-percent (0.52%) increase over typical projections had the pandemic not transpired, which Alagoz says is a credit to healthcare providers' ability to rebound and resume offering regular care within a few months.

"People were expecting like 10,000 or 15,000 additional deaths," says Alagoz, noting that any additional deaths are still premature losses of life. "Although at first the screening volumes and diagnostic procedures were delayed significantly, screening facilities and clinics were pretty good in catching up and they went back to normal very quickly. That's the primary reason the mortality impact is actually limited."

Focus on new faculty

Qiaomin Xie devises algorithms to navigate uncertainty in complex systems



Everything Qiaomin Xie had heard about UW-Madison led her to believe it would be an ideal landing spot for the next phase of her academic career.

As an incoming assistant professor in ISyE, she would be joining a faculty whose expertise in areas like optimization, machine learning, and healthcare and manufacturing systems would dovetail with her research in applied probability, stochastic networks and reinforcement learning. The growing data science influence and community on campus would allow for myriad collaborations across departments.

And both future and former colleagues had told her plenty of positives about Madison as a city.

Fortunately, when Xie finally visited in July 2021—about a month *after* she had accepted her new faculty position in ISyE—Madison lived up to her expectations.

"I love Madison," she says. "It's such a wonderful city. It's perfect in terms of size, in terms of location."

Xie joins ISyE after spending two and a half years as a visiting assistant professor at Cornell University. She earned her PhD in electrical and computer engineering from the University of Illinois in 2016, spending one semester as a research fellow at the Simons Institute for the Theory of Computing in Berkeley, California, and then was a postdoctoral researcher at Massachusetts Institute of Technology for two years.

Xie's work on the underlying decision-making policies that drive systems with elements of uncertainty and randomness (known as "stochastic" in mathematics) is crucial to computer networks and systems, such as data centers consisting of thousands of servers to host many applications.

While those applications stem from her training in electrical and computer engineering, Xie notes that the methodologies are natural fits for optimizing performance in systems such as the ride-sharing industry and hospitals—the kind of operations research that's a hallmark of ISyE—as well as for revenue management.

> "The main goal of my research is to understand the fundamental properties of these stochastic systems and to try to build a theoretical foundation of efficient algorithms and also practically useful algorithms that can be implemented in real-world systems," she says.

More recently, Xie has focused on a newer approach to complement her model-based techniques for algorithm design and performance analysis of various systems. This data-driven decision-making framework leans heavily on reinforcement learning, a machine learning paradigm for training intelligent agents to make sequential decisions under uncertainty, while also drawing on tools from game theory, optimization and statistical analysis.

"The goal here is to build the theoretical foundation for data-driven decision-making," she says.

Artificial intelligence companies like Google DeepMind have used reinforcement learning to achieve remarkable, eye-catching results in quickly mastering games like Go and chess, and the technique holds promise in areas such as robotics and autonomous vehicles. But it hasn't yet crossed the considerable divide from games to real-world applications, a gap Xie hopes to close through her work.

Despite her focus on the methodological and theoretical side, Xie says it's crucial to consider practical constraints and requirements when designing algorithms. And she enjoys helping students see the relevancy of modeling and data in their everyday lives. At Cornell, Xie taught a course called *Urban Analytics*, an introductory-level data analytics class that focused on applications like ride-sharing systems while teaching students how to clean, visualize and analyze data.

She'll teach ISyE 624: *Stochastic Modeling Techniques* during the fall 2021 semester, and she hopes to develop courses covering reinforcement learning and game theory in the future.

"It always feels so great to interact with students and make them realize the material and the knowledge they learn in the course actually can have a strong connection to their real life," she says.

ISyE poised to dive deeper into data, elevate equity

Years ago, when several of Laura Albert's mentors in operations research tried to nudge her to consider a career in academic administration, her initial reaction was less than enthusiastic.

Yet here she is, having taken over as the David H. Gustafson Chair of ISyE and speaking effusively over her enjoyment of strategic planning.

Since arriving at UW-Madison in 2013, Albert has further established herself as a prolific researcher and has prioritized sharing her insights with the broader public. But it took a combination of gaining leadership experience through several forums of the Institute for Operations Research and the Management Sciences and some self-reflection for Albert to envision a path into administration.

"I have always enjoyed giving back to early career researchers in the discipline, and academia is such a great place to do that because every year we're educating the next generation," says Albert, who served as the College of Engineering's assistant dean for graduate affairs from 2017-19. "The department chair and the assistant dean positions have given me unique opportunities to not just help students and colleagues on an individual level but also more on a structural level to make lasting policies and structures. This is a place where I really want our assistant professors, graduate students, and everyone to flourish."

And, as a department, Albert sees ISyE as particularly poised to thrive in an era where data science is informing nearly every field, including historic department areas of strength like healthcare systems, human factors, optimization and manufacturing.

The department rolled out a revamped undergraduate curriculum incorporating a stronger emphasis on data analytics in fall 2020, along with a new introduction to engineering analytics course that will serve as a core course for all UW-Madison engineering students. In recent years, ISyE has also hired faculty members—Justin Boutilier (fall 2019), Yonatan Mintz (fall 2020) and Qiaomin Xie (fall 2021)—whose research is driven by data science methodologies such as machine learning.

"We have a huge potential to lead in engineering analytics, data science, and artificial intelligence. There are opportunities that industrial engineers can uniquely tackle, and we can build upon this outstanding research ecosystem here at UW-Madison," says Albert, pointing to the creation of the American Family Insurance Data Science Institute and the School of Computer, Data & Information Sciences in recent years.

And she's also keen to continue driving ISyE forward in the areas of equity and inclusion in student recruitment and retention, education and research. Associate Professor Nicole Werner will be leading the department's new equity task force, while Albert and Assistant Professor Gabriel Zayas-Caban have both earned awards for their efforts to improve representation in the field.

Werner, through her work on the hidden workloads of family caregivers for people with dementia and children with medical complexity, is among the ISyE faculty members whose research explores areas of inequity. Ditto for Boutilier's research on healthcare in international, low-resource settings, Mintz's on bias in automated decision-making, Albert's own work on public sector infrastructure decisions, and others across the faculty.

"We have faculty who have interest in application areas where equity is really at the forefront," says Albert. "So I think for us, it's particularly driven by the research. It kind of spreads everywhere."

Operations research shows effectiveness of substance-use diversion program

In 2017, the Madison Police Department launched the Madison Addiction Recovery Initiative (MARI), a collaborative effort with a host of local agencies aimed at creating a more effective response to the opioid epidemic.

Rather than arresting individuals who had committed a nonviolent, drug-use-related crime, officers could offer eligible adults a personalized treatment program for substance-use disorder. The diversion program, which has since evolved into the Madison Area Addiction Recovery Initiative, and similar efforts in communities across the country offer an alternative to the use-arrest-use cycle (and possible incarceration) that hinders those individuals and strains the criminal justice system.

In order to accomplish that mission, however, the programs need to do more than merely exist. They need to be effective.

Working in close partnership with the MARI team, ISyE operations researchers analyzed the initiative's performance. By their estimate, MARI reduced the odds of recidivism within six months. The team published its findings—the first in an ongoing study—in the journal *Drug and Alcohol Dependence*.

"It's promising; that's the biggest thing that we're trying to answer. At least in six months, is it doing what we expect it

to? Is it reducing crime?" says Veronica White, a PhD student who was first author on the study, which is part of her dissertation work on the opioid crisis in Dane County and the effects and costs of various potential community initiatives and policies.

The team, which also included Jane R. and Jack G. Mandula Assistant Professor Gabriel Zayas-Caban, PhD student Sebastian Alvarez Avendano and Professor and David. H. Gustafson Chair Laura Albert, used three types of analyses—all methods that fall under the bucket of causal inference from observational data—to parse the MARI data. (To account for the lack of a randomized assignment that is typical of a controlled trial, since there was no control group of MARI-eligible individuals who didn't participate in the program, Alvarez employed a newer approach to estimating the complier average causal effects analysis in order to compare program participants to a historical comparison group.)

White says the research group's partnership with the MARI team was vital in providing deeper context for the data and enabling insightful analysis. She helped with data collection and met regularly with Aleksandra Zgierska (now a professor at the Penn State College of Medicine and a former UW-Madison faculty member and principal investigator for MARI), and Joe Balles (a retired Madison Police captain who's coordinated MARI through the nonprofit Safe Communities Madison-Dane County).

"I hope it can be a model for future initiatives, in terms of how academic researchers should be involved from the beginning," says White, who is co-advised by Zayas-Caban and Albert. "Not only were we able to use different tools that they had probably never heard of, like causal inference, but we were also able to help make sure they were capturing the data that could use those tools."

The group will next look at MARI's effects on recidivism at 12 months, and White also sees opportunities to probe the program's influence on the health outcomes of participants. Zayas-Caban notes that while diversion programs have grown, thorough analyses like this one have been slower to follow.

"These kind of community policing initiatives are popping up everywhere," he says. "This is, I think, pretty close to being one of the first studies to really systematically collect this data and analyze it in an academic environment."

Pascale Carayon speaks at the inaugural Wisconsin Institute for Healthcare Systems conference in 2017. Carayon launched the institute as its founding director.

Lasting Legacy:

Carayon shapes healthcare systems engineering through research, mentorship

Pascale Carayon's curriculum vitae is 72 pages long, detailing the litany of awards, publications and lectures the widely respected human factors engineering scholar has accumulated over the course of her more than 30-year career.

What it doesn't list are the numerous times she's set aside any zeal for personal accomplishment to include a junior faculty member on a major research grant, connect young researchers from different sides of the UW-Madison campus and beyond, or quietly put forward a current or former PhD student for an opportunity.

"She does a lot of work behind the scenes that she doesn't even tell you she's doing," says former advisee Abigail Wooldridge (MS '13, PhD '18), now an assistant professor at the University of Illinois. "Things would just kind of materialize for you."

Or, as Michelle Rogers (MS '98, PhD '02), now an associate professor at Drexel University, puts it: "She has definitely spoken up for me when I wasn't in the room."

Carayon retired in August 2021, capping a remarkable tenure in which she established herself as one of the world's foremost experts in applying human factors and industrial engineering approaches to the healthcare system. But she's also forged a reputation as an uncommonly devoted mentor, particularly for women in engineering.

"Pascale has been so dedicated to supporting and shaping the future of the field," says Harvey D. Spangler Assistant Professor Nicole Werner. "The scope of her influence as a mentor definitely rivals the scope of her influence as a researcher. The two are intertwined."

And Carayon's research influence on the field of healthcare systems engineering has been substantial. Werner was an intern at The Johns Hopkins Hospital as an undergraduate student at George Mason University when the resident human factors engineer shared Carayon's 2006 paper detailing the Systems Engineering Initiative for Patient Safety (SEIPS) model, a framework for analyzing and improving healthcare systems and safeguarding patients.

The SEIPS model, which Carayon has subsequently updated twice, became a foundational piece of her work in healthcare. As director of the interdisciplinary Center for Quality and Productivity Improvement (CQPI) at UW-Madison, she shared the model with clinicians, healthcare leaders and other professionals through SEIPS short courses. She also founded and directed the Wisconsin Institute for Healthcare Systems Engineering (WIHSE) to better connect healthcare and engineering researchers and practitioners.

SEIPS grew out of research that began two decades earlier when Carayon was a PhD student with Professor Michael J. Smith.

Together, Carayon and Smith developed a model for improving job design by balancing stressful requirements, which they published in 1989.

Carayon's work on job design gradually shifted into healthcare settings, as did her early research on the impact of computer technology on workers and processes.

She's studied the implementation of electronic health records systems, designed and evaluated various health information technologies such as clinical decision support for diagnosing pulmonary embolism and an integrated display to aid teamwork in pediatric trauma care transitions, and, through the SEIPS model, developed ways to improve patient safety and clinician well-being.

Carayon says she learned early on the importance of getting out into real workplaces and talking to the workers whose jobs would be affected by her research.

"My lab is not a physical space in the Engineering Centers Building. My lab is going out and talking to people and observing them—being in the real environment. And I really, really enjoyed that," she says. "Sometimes it was talking to people, sometimes it was observing them, sometimes it was convincing them to do a survey and to collect data from them. So there was always that connection to people in their real environment that I liked. That gave me a sense that what I was doing was important."

FACULTY NEWS

David H. Gustafson Chair and Harvey D. Spangler Faculty Scholar Laura Albert landed a data science grant through the American Family Funding Initiative for a project applying machine learning tools to the insurance industry.

Professor Emeritus Vicki Bier was appointed to the U.S. Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards.

Harvey D. Spangler Associate Professor Nicole Werner received a grant from the National Institutes of Health to create an information technology tool to support caregivers of people with dementia. Werner was also elected as president-elect of the Division of Applied Experimental and Engineering Psychology of the American Psychological Association.

Duane H. and Dorothy M. Bluemke Professor Robert Radwin received the International Ergonomics Association's fellowship award. Radwin was also appointed the next editor-in-chief of *Human Factors: The Journal of the Human Factors and Ergonomics Society.*

Associate Professor Kaibo Liu won the Institute of Institute of Industrial and Systems Engineers' 2021 Award for Technical Innovation in Industrial Engineering.

Proctor and Gamble-Bascom Professor Oguzhan Alagoz was elected a fellow of the IISE.

Harvey D. Spangler Professor Jeff Linderoth received a $416,547 grant from the U.S. Office of Naval Research to examine and improve the use of mathematical models in naval defense.

Vilas Distinguished Achievement Professor Shiyu Zhou published a new textbook, *Industrial Data Analytics for Diagnosis and Prognosis.* One of Zhou's papers also received a best paper award from *IISE Transactions*, while another (in collaboration with UW E-Business Chair Professor Raj Veeramani) received honorable mention from the journal.

STUDENT NEWS

PhD student Akash Deep earned the E. Wayne Kay Graduate Scholarship from the SME Education Foundation.

PhD student Minhee Kim received the Mary G. and Joseph Natrella Scholarship from the American Statistical Association, as well as the Gilbreth Memorial Fellowship from IISE.

Undergraduate Jan Wodnicki earned a Hilldale Fellowship to support his research project using machine learning to improve treatment of diabetic foot ulcers in India.

Human factors work shows hidden ingenuity of family caregivers

In a hospital room, all the equipment for a gastrostomy feeding fits together as intended, delivering nutrition directly to the patient's stomach. It's a setting designed explicitly for patient care, after all.

The average home has a decidedly different setup. And for families with children with medical complexity (those who have significant chronic health conditions that affect multiple organ systems and require ongoing care), integrating medical devices into their existing physical environments can prove frustrating.

Those families also are resourceful, devising workarounds to better accommodate and sustain their children's equipment in spite of limited support from device companies and healthcare providers.

To explore those workarounds, members of the lab of Harvey D. Spangler Assistant Professor Nicole Werner and collaborators visited 30 families with children with medical complexity to conduct interviews about the barriers they faced and the strategies they developed in response. They published their study in the journal *Pediatrics*.

"A lot of work has been focused on trying to make healthcare and devices safer in clinical settings, because that's where they're historically used the most," says Werner. "That's important, but there's just this gap, where we don't really know how they're being used in the home."

By highlighting this hidden work, PhD student Hanna Barton, who led the study, hopes to give medical providers a window into the homes of their patients.

"If we can get clinicians thinking about what it's like to do this at home, it might alter the conversations they have, like preparing someone for what life is going to be like now with a gastrostomy tube and the care you're going to need to provide," they say. "It's not only about all the clinical diagnoses and medications, but it's also about how that fits into your day-to-day life."

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Bright idea

PhD student Rebecca Alcock is leading a pilot project at Eagle Heights Community Gardens on the UW-Madison campus, where she and student volunteers installed solar panels and electric bicycles.

It's part of her effort to create a renewable energy and transportation system that could be employed by rural healthcare clinics in sub-Saharan Africa. Alcock, who received a research award from the UW-Madison Global Health Institute to support her project, is working with her advisor, Assistant Professor Justin Boutilier, and Grainger Engineer Design Innovation Lab Director Lennon Rodgers.

Alcock was also one of 12 UW-Madison faculty, staff and students to be named a 2021-22 Morgridge Fellow through the Morgridge Center for Public Service.