Carilion Medicine

SPRING/SUMMER 2018

In partnership with the Virginia Tech Carilion School of Medicine and Research Institute

SPECIAL REPORT

The Quality Issue

COVER ILLUSTRATION: NEIL STEVENS; ILLUSTRATION: GRACIA LAM (ABOVE)

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CARILION MEDICINE SPRING/SUMMER 2018

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DOUBLE STANDARDS: Roanoke City, which has one of the lowest health rankings in Virginia, is enclosed within Roanoke County, whose health ranking is one of the highest. That discrepancy has caused Carilion Clinic to look beyond the traditional boundaries of health care.

Features

A RECENT STUDY REPORTED THAT MEDICAL errors are the third leading cause of death in the United States, ranking just behind heart disease and cancer. While much has been done to reduce medical errors and improve patient safety, mistakes can still happen. Often circumstances beyond anyone's control render a bad outcome inevitable.

Patients and their families—the first victims—aren't the only ones affected. Clinicians are too, and the effects of being a "second victim" can be devastating.

Years ago, I knew of a young intern caring for a pregnant woman with severe preeclampsia and insulin-dependent diabetes. The mother was being induced under the care of the attending physician and the intern. The attending left the room, with the expectation that the intern would be closely following the patient. When the attending returned, she could see multiple subtle decelerations in the fetal heart rate, indicating decreased oxygenation. The baby was delivered by emergency C-section and whisked away to the NICU.

I want you to consider two possible outcomes for the intern. First, his superiors could have blamed and reprimanded him. Or they could have given him support, recognizing that he could be emotionally affected by his oversight and encouraging him to learn from the experience.

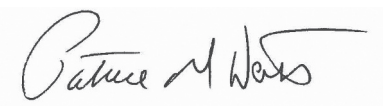
Throughout my career, I've witnessed adverse events, some more serious than others. And I've learned a great deal about what it means to be a second victim.

It turns out that more than 40 percent of providers are second victims and about one-third of them experience emotional distress, placing them at risk for depression, burnout, and feelings of guilt and shame that can be long lasting. They may also experience shock and hopelessness, sleep disturbance, social avoidance, intrusive thoughts, and nightmares. Interestingly, these emotions and reactions can be similar to those of post-traumatic stress disorder. Recovery can take years, and some clinicians never rebound.

Hospital systems' internal review processes for medical errors often compound the problem. They can too easily devolve into a "name, blame, shame game." We need to move beyond that to a just culture, one that differentiates between competent professionals who make mistakes and those who behave recklessly and should be punished.

We physicians all pledge to avoid harm, and we are often held to standards of perfection by society, peers, and, above all, ourselves. Yet we are only human. We deserve empathy and support after a stressful outcome or event.

When we put on our white coats, let's not turn off our hearts.



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Carilion Clinic is a nationally ranked integrated health care system headquartered in Roanoke, Virginia. Its flagship, Carilion Roanoke Memorial Hospital, is the clinical affiliate of the Virginia Tech Carilion School of Medicine and Jefferson College of Health Sciences.

PHOTO: JARED LADIA

On the pulse of the Carilion Clinic community

in brief

ASSUMING THE MANTLE

It was a hike with her Girl Scout troop that led Nancy Howell Agee to a career that most recently culminated in being the top elected official of the American Hospital Association.

Agee, then 15, tripped and slid down a small mountain. Although the clinicians at the emergency department found no broken bones, they did diagnose a tumor in her knee. It was the care she received over the next two years that motivated her to become a nurse—and an impassioned advocate for patients.

Decades later, Agee, president and chief executive officer of Carilion Clinic, assumed the chairmanship of the American Hospital Association's board of trustees.

Although she began her tenure in January, her official investiture ceremony took place in May, at the association's annual membership meeting. There Agee opened her investiture address by describing her experiences as a teenage patient.

PLEDGE TO SERVE: "Our commitment to excellence demands our continual focus on making care better and more affordable for our patients," said Nancy Howell Agee in her investiture ceremony. "They are the reason we are here and why we do what we do."

"The doctors and nurses who cared for me then inspired me, and the work of caregivers all across this country inspires me now—inspires me to make a difference to the patients who put their trust in us," Agee said. "In my opinion, there's not much that's more important."

In her role as chair, Agee works to advance health care nationally and to be an agent for change in the field. During her address, Agee spoke about the association's Value Initiative, which provides thought leadership on the issue of affordability. She also touched on the association's commitment to drive excellence.

"We cannot sit on the sidelines as health care changes around us," Agee said. "We must lead—for all our patients. We must lead for our teams, the caregivers and staff who demonstrate care and compassion every day. Together, with open ears and eyes and hearts, we will be the catalyst for change in a sector that is ripe for it."

Agee, who has served as Carilion's president and CEO since 2011, joined the American Hospital Association's board of trustees in 2015, serving on its executive, operations, and audit committees. She has also served on the association's Health Care Systems Governing Council and represented the association as a commissioner on The Joint Commission board.

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leadership

Medical School to Host International Conference

The Virginia Tech Carilion School of Medicine will host the 23rd Annual Meeting of the International Association of Medical Science Educators (IAMSE). Set for June 7–11, 2019, the meeting is expected to draw more than 500 basic science and clinical educators from across the globe to Roanoke, Virginia.

"The event organizers saw the school successfully hosted a large conference a few years ago, the 2015 Collaborating Across Borders conference, which attracted nearly 700 health care professionals from across North America to Roanoke, and they felt confident we could accommodate this annual meeting," said lead organizer Richard Vari, Ph.D., senior dean for academic affairs at the medical school and the current president of IAMSE.

"I look forward to bringing my peers to the place I've called home for the last decade," Dr. Vari said.

PHOTO: STEPHANIE KLEIN-DAVIS, COPYRIGHT, *THE ROANOKE TIMES*, REPRINTED BY PERMISSION

tribute

Founding Medical Dean to Retire

After more than a decade at the helm, Cynda Johnson, M.D., M.B.A., founding dean of the Virginia Tech Carilion School of Medicine, has announced plans to retire. She will stay in her position while a search for her replacement is under way.

"Being founding dean of the Virginia Tech Carilion School of Medicine and creating a school from scratch has been an amazing experience," said Dr. Johnson. "From the unique, patient-centered curriculum that we created, to the high-caliber students and graduates and faculty who deeply care about teaching and mentoring, leading this school has exceeded my expectations in every way."


Johnson

In 2007, Carilion Clinic, Virginia Tech, and the governor of Virginia announced plans for the Virginia Tech Carilion School of Medicine and Research Institute. Dr. Johnson arrived in Roanoke a year later to oversee the creation of the new allopathic medical school.

The school welcomed its first class in August 2010 and received full Liaison Committee for Medical Education accreditation after that class graduated in May 2014.

During Dr. Johnson's tenure, five classes of students have graduated. Each class has exceeded the national mean score on Step 1 and Step 2 licensing exams and has earned a 100-percent match rate to residency programs.

"Not too many people these days can say they built a medical school from the ground up, particularly one with such a stellar reputation," said Nancy Howell Agee, president and chief executive officer of Carilion Clinic. "We knew we needed someone special for the job, and Cynda surpassed expectations—not only ours, but the community's—at every step of the way."

Dr. Johnson built the school under a still-unique public-private partnership between Virginia Tech and Carilion Clinic. "That presented its own set of challenges and opportunities, but her hard work has paid off in numerous ways," said Agee. "The extraordinary success that the school has seen under Cynda's leadership isn't a surprise to anyone who knows her. I'm proud to have had the opportunity to work with such a leader."

The school received more than 1,600 applications for its charter class; in each of the last two years, it received more than 4,000 applications for just 42 spots.

"One of the amazing things about starting a new school was we could look at the trends and see what the next generation of physicians will need to be successful, such as training in interprofessionalism and research to improve patient outcomes, and build the curriculum to meet those needs. That is harder to do in well-established schools," said Dr. Johnson. "We also built the curriculum to remain flexible so we can continually adapt and ensure we can meet our mission to develop the next generation of physician thought leaders."

The medical school has been an independently accredited private school; in July, though, it will be integrated into Virginia Tech as the university's ninth college, with Carilion Clinic as a partner providing faculty and the clinical experience for students.

"Thanks to Cynda's tireless work, the Virginia Tech Carilion School of Medicine is one of the top research-intensive medical schools in the country," said Timothy Sands, Ph.D., president of Virginia Tech. "Her leadership over the past decade will support the success of its students, faculty, and staff for decades to come, and has established the school as a driving force in the development of the Virginia Tech Carilion Health Sciences and Technology Campus."


Students practicing disaster scenarios.

Jefferson College of Health Sciences to Explore Partnership

Jefferson College of Health Sciences, a longtime teaching affiliate of Carilion Clinic, is exploring a public-private partnership with Radford University, a comprehensive public university in southwestern Virginia. The partnership, slated for 2020, would create the second largest nursing program in the state.

"Jefferson College already enjoys a wonderful relationship with Radford University," said Nathaniel L. Bishop, D.Min., president of Jefferson College. "We're combining forces to create something even bigger and better for the entire commonwealth."

In its 35-year history as an accredited institution, Jefferson College has grown from 200 students to more than 1,150. One of the region's leading producers of nursing and allied health professionals, the college is listed among the top 10 in Virginia.

"Carilion Clinic is proud to have nurtured Jefferson's growth, as it established a reputation for developing ethical, knowledgeable, competent, and caring health care professionals," said Nancy Howell Agee, president and chief executive officer of Carilion. "Joining the Radford University family is a wonderful opportunity for Jefferson College. And now is the right time as the vision for a health sciences and technology campus in Roanoke comes to life."

Students from both Radford and Jefferson College would have access to enhanced educational opportunities, including clinical rotations and internships, and Radford would continue to partner with Carilion in sharing facilities and research resources.

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PHOTOS: DAVID HUNGATE

VETERANS UNDER PRESSURE

Fireworks on nights other than the Fourth of July and New Year's Eve might suggest nothing more than inconsiderate neighbors, but for veterans with post-traumatic stress disorder (PTSD), the shock of noise and light may trigger a deeply learned expectation of danger.

Scientists at the Virginia Tech Carilion Research Institute have found that people with PTSD have an increased learning response to surprising events. While most everyone reacts to surprise, people with PTSD tend to pay even more attention to the unexpected.

The study was published in January 2018 in *eLife*, an open-access journal published by the Howard Hughes Medical Institute, the Max Planck Society, and the Wellcome Trust.

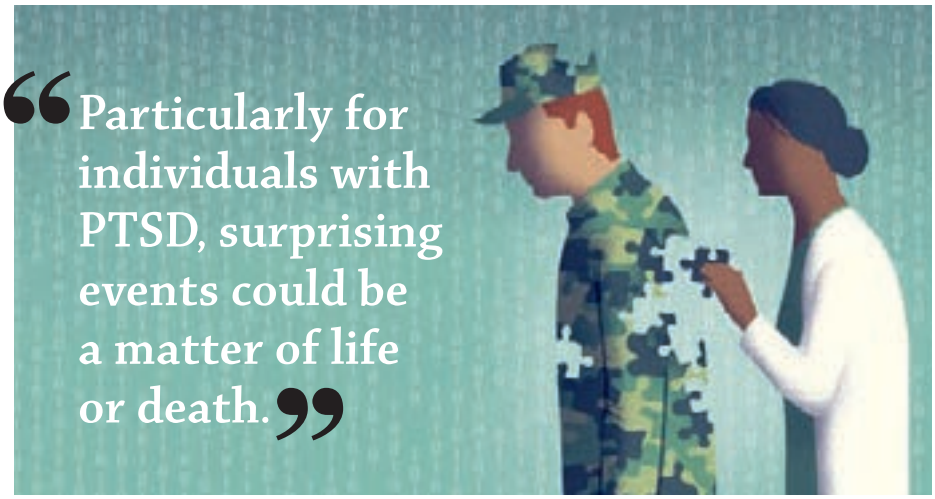
"Disproportionate reactions to unexpected stimuli in the environment are a core symptom of PTSD," said Pearl Chiu, Ph.D., associate professor at the research institute and the lead author on the study. "These results point to a specific disruption in learning that helps to explain why these reactions occur."

Dr. Chiu and her team used functional magnetic resonance imaging to scan the brains of 74 veterans, all of whom had experienced trauma while serving at least one combat tour in Afghanistan or Iraq. Some of the study participants were diagnosed with PTSD, while others were not. In the functional MRI, participants played a gambling game, in which they learned to associate certain choices with monetary gains or losses.

"Computer science and mathematics have given us new tools to understand how the brain learns," Dr. Chiu said. "We used these tools to study whether and how learning might play a role in PTSD. These results suggest that people with PTSD don't necessarily have a disrupted response to unexpected outcomes; rather, they pay more attention to these surprises."

The researchers found that people with PTSD had significantly more activity in the parts of their brains associated with how much attention they paid to surprising events when the learning task threw an unexpected curve ball their way.

"Fireworks unexpectedly going off after a person has exchanged fire in the field can trigger an overestimation of danger," said Brooks King-Casas, Ph.D., the associate professor at the research institute who co-led the study. "Particularly for individuals with PTSD, surprising events—noise or otherwise—could be a matter of life or death. The study shows that while everyone is affected by unexpected events, in PTSD extra attention is given to these surprises."



briefings

Small Wonder

Carilion has opened a new mini-clinic at Carilion Roanoke Community Hospital. The first of its kind in the area, the clinic seeks to enhance the role of academic nursing in the community clinic network and to allow nursing students the opportunity to learn about community-based practice. The clinic also helps increase access to care for uninsured and underinsured patients.

Partnership to Focus on Brain Injury

How can you accurately diagnose a mild traumatic brain injury that has subtle or no physical signs yet can cause long-term damage? Carilion clinicians are teaming up with Virginia Tech Carilion Research Institute scientists, University of Virginia researchers and clinicians, and experts from the biotechnology company BRAINBox Solutions to aid in the diagnosis and management of mild traumatic brain injuries. By studying patients' cognitive performances during advanced brain imaging, the team will determine the accuracy of a blood-based test that can be administered directly at the point of care.

ILLUSTRATION: DAVIDE BONAZZI; PHOTOS: MARK LAMBERT, TOP RIGHT; DAVID HUNGATE, RIGHT

BREATHS OF RELIEF: A patient in the early 1950s receives lifesaving support from an iron lung, a mechanical respirator used to combat the paralysis that can compromise polio patients' breathing.

THE LITTLE HOSPITAL THAT COULD

At the height of the polio epidemic, Roanoke did the impossible to save countless young lives.

The summer of 1950 was a scorcher in southwestern Virginia, and power surges were common. The moment the electricity failed, Memorial and Crippled Children's Hospital employees—from orderlies to cooks, maids, and office workers—would rush to the polio ward. There they pumped iron lungs by hand until the power returned.

The little hospital on the hill—which would eventually grow into Carilion Roanoke Memorial Hospital—could reasonably care for 40 polio patients at a time. That year, the hospital treated an estimated 450, with patients in iron lungs even lining the hallways.

"It was awful," one of the hospital's physicians, the late Louis Ripley, M.D., recalled decades later. "Whole floors of the hospital were full of patients, infants to adults. And many died."

At the height of the nation's polio epidemic, the hospital became a regional magnet for those stricken with the virus. No one—not the nurses or doctors, the physical therapists, the engineers who oversaw the transport of patients in iron lungs, or the student nurses who rocked the beds of patients struggling to breathe—questioned whether they would be infected. They just pitched in, and the entire community rallied in support, from donating theatre ticket sales to equipping moving vans and rail cars with generators to accommodate patients in iron lungs.

"There was so little we could do," Dr. Ripley said. "It was devastating. Everyone worked their hearts out."

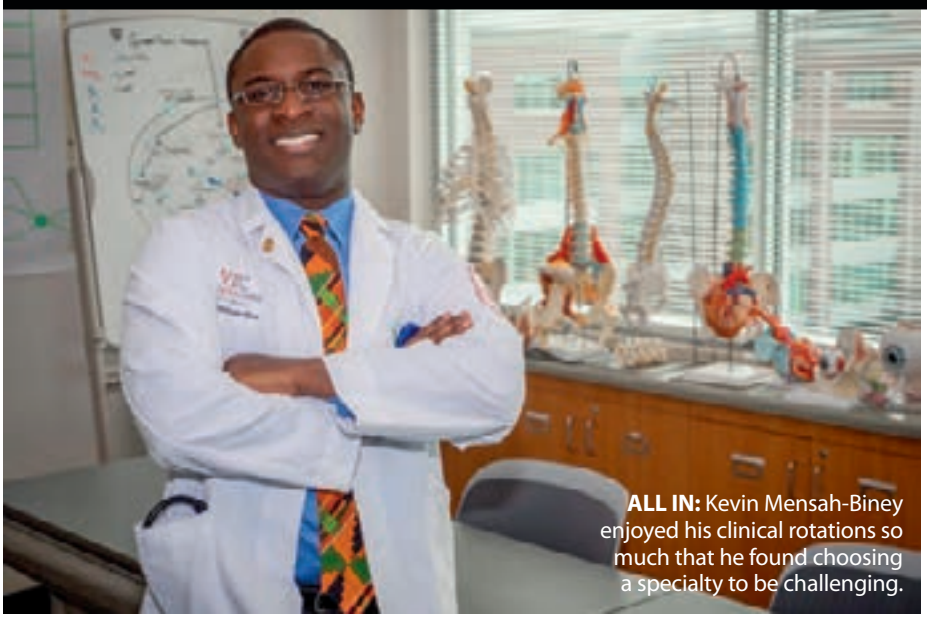
Years later, after the introduction of the Salk vaccine, the Polio Foundation would feature the hospital's response to the epidemic in a movie shown nationally as part of a March of Dimes campaign.

"Those iron lungs never missed a beat," Dr. Ripley said. "Everyone just worked together to get it done. It was amazing." CM

PHOTO: CARILION CLINIC ARCHIVES

grand rounds

Education at Carilion Clinic and its affiliates



ALL IN: Kevin Mensah-Biney enjoyed his clinical rotations so much that he found choosing a specialty to be challenging.

A Passion for Medicine

Kevin Mensah-Biney is known among his fellow students at the Virginia Tech Carilion School of Medicine as a trivia buff.

"Not really trivia," he said with a grin, "more like random facts."

His talent for storing and retrieving information has served him well academically. Mensah-Biney, the son of Ghanaian parents, grew up in Asheville, North Carolina, where he showed an aptitude—and zest—for science at an early age.

One element of his medical school experience he found particularly helpful was the intensive research requirement. His project, under the mentorship of Sandy Fogel, M.D., associate professor of surgery, looked at patients transferred to Carilion Roanoke Memorial Hospital for emergency surgery to determine the effects of distance and time on their outcomes. The research was published in *The American Surgeon* last year, and Mensah-Biney presented a poster at the 2017 Annual Scientific Meeting of the Southeastern Surgical Congress.

To have his research recognized on a national level, Mensah-Biney said, speaks to the rigor and quality of the school's research program. Since 2010, when the Virginia Tech Carilion School of Medicine welcomed its first class, 53 students have had research published in national journals. Students have also presented 234 posters and 39 oral presentations at regional, national, and international meetings.

"Having research experience is something that keeps us competitive as we apply for residencies and later when we go into practice," Mensah-Biney said. "I can't imagine going through medical school and not having the research requirement."

Mensah-Biney also found his clinical rotations invaluable—and enjoyable. "They made it hard for me to choose a specialty," said Mensah-Biney, who eventually settled on surgery. All this experience, he added, has prepared him well for future years of service.

"Making an impact on others," he said, "is something I've always wanted to do."

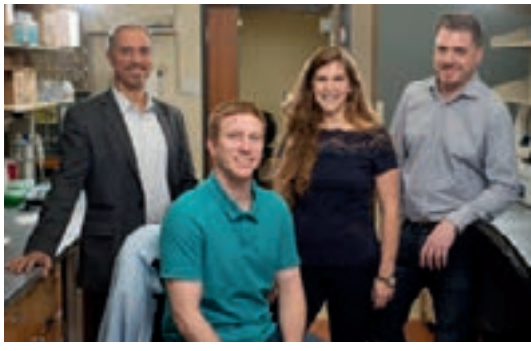
STUDENTS RECEIVE PRESTIGIOUS SUPPORT

Two students in Virginia Tech's Translational Biology, Medicine, and Health doctoral program have won National Institutes of Health fellowships for research aimed at protecting people with cardiac problems.

Tristan Raisch and Carissa James will each receive a Ruth L. Kirschstein National Research Service Award Individual Predoctoral Fellowship, a highly selective honor conferred on top U.S. graduate students in health science–related fields.

Under the mentorship of Steven Poelzing, Ph.D., associate professor at the Virginia Tech Carilion Research Institute and co-director of the doctoral program, Raisch seeks to resolve a controversy about the roles that extracellular spaces next to gap junctions play in the conduction of electrical signals across the heart.

While James also studies gap junctions, she focuses on alterations in the assembly of these structures, which allow heart cells to communicate with each other. With mentor Jamie Smyth, Ph.D., assistant professor at the research institute, James seeks to expand understanding of how proteins are synthesized and play a role in healthy cellular communication.

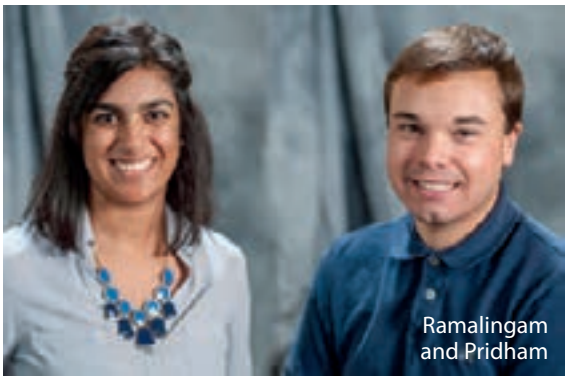


From left: Dr. Steven Poelzing, Tristan Raisch, Carissa James, and Dr. Jamie Smyth

PHOTOS: DAVID HUNGATE

DOCTORAL PROGRAM GRADUATES FIRST STUDENTS

When NithyaPriya Ramalingam and Kevin Pridham donned caps and gowns for Virginia Tech's recent commencement, they made history as the first two graduates of the Translational Biology, Medicine, and Health doctoral program. Yet their impact extends far beyond a ceremony.


Ramalingam and Pridham

"These students represent the breadth of the research focus areas available through the program," said Michael Friedlander, Ph.D., executive director of the Virginia Tech Carilion Research Institute and vice president for health sciences and technology at Virginia Tech. "Nithya is highly focused on health implementation to improve quality of life for the elderly, as well as preventing obesity, while Kevin is dedicated to understanding and correcting the molecular processes that underlie the deadliest form of brain cancer, glioblastoma multiforme. They are on the cusp of promising careers as biomedical and health scientists."

EPILEPSY IN NIGERIA


Anyanwu

Nigeria has few trained neurologists—and that's not the only challenge for people with epilepsy there. "Sadly, due to cultural beliefs, most patients with epilepsy are stigmatized, as it is generally believed that their condition is due to a spiritual attack or fetish practices," said Chinekwu Anyanwu, M.D., medical director of Carilion's EEG laboratory. In January, Dr. Anyanwu spearheaded a two-day epilepsy conference in southeastern Nigeria for primary care physicians, pediatricians, and neurologists. A community walk followed, to help dispel myths about the disease.

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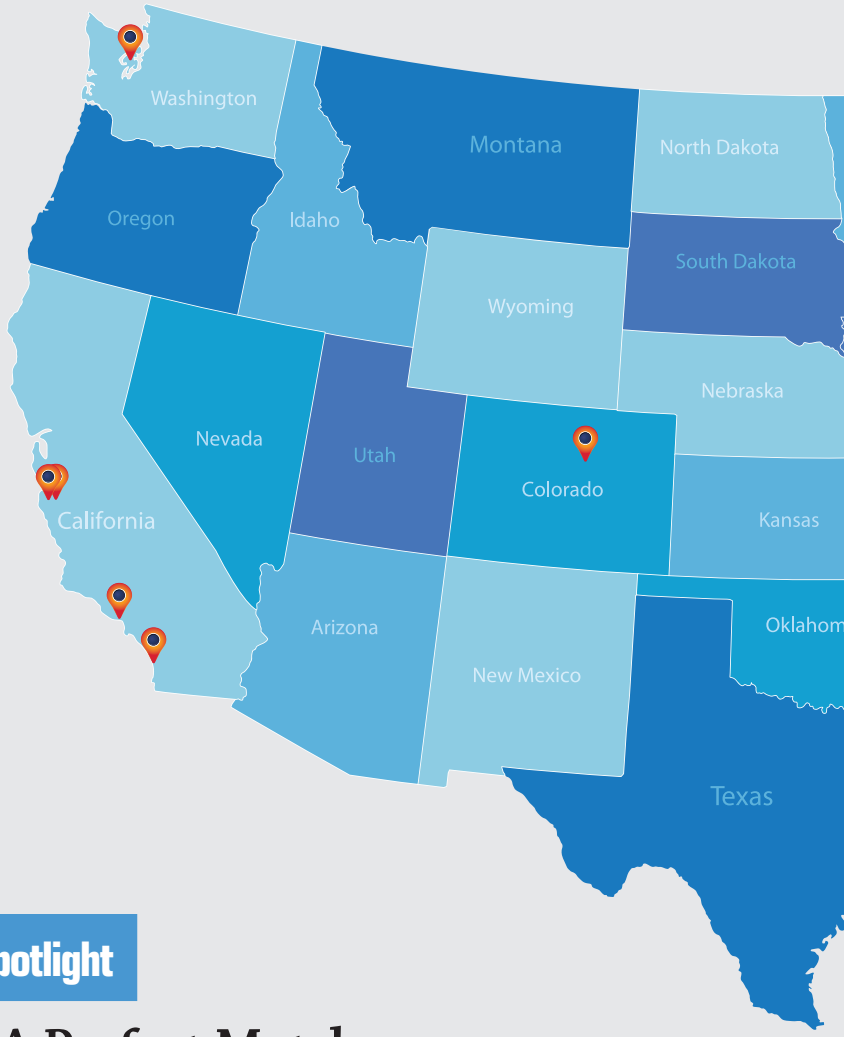
Dr. Aubrey Knight, senior dean for student affairs, plays the Mad Hatter.


Two students take advantage of the option to match as a couple.



spotlight

A Perfect Match

When the suspense ended, all 41 members of the Virginia Tech Carilion School of Medicine's class of 2018 matched. It was the school's fifth Match Day—and the fifth time that its match rate was 100 percent.

During Match Day 2018, themed "March Match Madness," members of the graduating class learned where they would be spending their residencies. Beginning at noon, students at the Virginia Tech Carilion School of Medicine—as well as students in medical schools across the country—opened envelopes to see where their next chapter would unfold. Members of the class will go into programs representing 15 specialties in 16 states.

PHOTOS, THIS SPREAD: DAVID HUNGATE AND JARED LADIA (DR. ANYANWU)

A medical student expresses her glee upon getting her first-choice residency.

A student coyly tests the opacity of his envelope before the strike of noon.

MOST POPULAR SPECIALTIES, BY THE NUMBERS

5	General Surgery	5	Diagnostic Radiology
5	Internal Medicine	3	Neurology
5	Obstetrics–Gynecology	3	Psychiatry

A NEW VISION FOR SMOKERS

The research project of Perisa Ruhi, a member of the Virginia Tech Carilion School of Medicine's class of 2018, offers new findings to help change smoking behaviors. Ruhi found that smokers were more likely to value a future without cigarettes when envisioning future events with smoking-related illness symptoms, such as lung cancer.

Previous research has found that cigarette smokers discount or devalue future rewards at a higher rate than nonsmokers, a tendency called delay discounting.

Using an online crowdsourcing platform, Ruhi recruited and randomly assigned 199 smokers to one of four groups: those who imagined positive future events, those who added symptoms of smoking-related illness to their imagined positive future events, and two control groups for validity.

Ruhi's study showed cigarette craving diminished significantly in both groups assigned to imagine the future. "But when we measured delay discounting, things got even more interesting," she said.

Ruhi found that participants who envisioned positive future events were less likely to devalue the future and, unexpectedly, participants who envisioned themselves with a smoking-related illness showed the opposite effect: It led them to devalue the future more. Yet for both groups, episodic future thinking seems to protect against circumstances that increase impulsivity.

Ruhi conducted the study under the mentorship of Warren Bickel, Ph.D., director of the Addiction Recovery Research Center at the Virginia Tech Carilion Research Institute, and Jeff Stein, Ph.D., research assistant professor at the center.

The Virginia Tech Carilion School of Medicine is one of a handful of medical schools in the country to require an intensive longitudinal research project, a fact that heavily influenced Ruhi's decision to go there.

"I've been able to conduct a research project from the ground up," she said. "I wouldn't have gotten this opportunity anywhere else."

Ruhi

THE QUALITY ISSUE

In *The Checklist Manifesto*, writer and surgeon Atul Gawande, M.D., M.P.H., paints by numbers the world of clinical care: more than 13,000 different diseases, syndromes, and types of injuries; at least 6,000 drugs; more than 4,000 medical and surgical procedures, each with a range of requirements, risks, and protocols. Dr. Gawande concludes his portrayal of the complexity of medicine with an understatement: "It is a lot to get right."

The stakes in medicine are enormously high. When an error occurs, the consequences for patients can be life altering or even life ending. The impact on the caregivers involved—the "second victims"—can be dramatic as well.

While to err may be human and forgiveness of clinical missteps divine, health care systems can adopt a range of strategies to ensure impeccable care.

ILLUSTRATION: NEIL STEVENS

chasing ZERO

Carilion Clinic is striving to eliminate patient harm completely. **BY DAVID BUMKE**

CATHETER-ASSOCIATED URINARY TRACT INFECTIONS ARE A MAJOR PROBLEM FOR HOSPITALS. They can happen whenever patients need to have a urinary catheter inserted into their bladders, which is a common procedure, particularly after surgery. These infections, also known as CAUTIs, account for 75 percent of all urinary tract infections in hospitals, and health care professionals have been trying for years to find ways to make them less commonplace.

So when Carilion Clinic and its affiliated hospitals decided to address the problem, many observers were skeptical. "People said we couldn't do it," said Nancy Howell Agee, president and chief executive officer of Carilion and the current chair of the American Hospital Association's board of trustees, in a recent address to the National Quality Forum.

Led by Thomas Kerkering, M.D., medical director of hospital infection control, Carilion introduced protocol changes that have been remarkably effective. With 99 percent

compliance from providers, who have embraced a better approach to something that had been part of their routine for years, CAUTIs dropped from 101 per year to 77, and Carilion is currently on track for a 30- to 40-percent reduction again in 2018. Carilion took a systematic and holistic approach that included introducing transparency about infections.

"Our goal was to eliminate all preventable CAUTIs," says Dr. Kerkering, "and we are very close to that with our current numbers."

Carilion's efforts to reduce CAUTIs are part of an aggressive push to limit harm of any kind. Other initiatives have also borne fruit. By adjusting systems and expanding resources, Carilion Roanoke Memorial Hospital has reduced acute inpatient mortality by 15 percent and surgical site infections after common procedures by more than half. The overall Patient Safety Index has improved, and *Clostridium difficile* infections have fallen to well below national averages.

Carilion's goal, though, is to eliminate not just some mistakes, but all of them.

"In five years, I want Carilion to be recognized as a global leader of quality and continuous improvement in health care," Agee announced in an address at the International Health Forum in Taipei, Taiwan. "Chasing zero is a part of that."

Refining the System

Traditionally in health care, when patient safety problems arose, the default response was either to punish the providers involved or to provide them with more education, says Jonathan Gleason, M.D., vice president of clinical advancement and patient safety (CAPS). Yet as important as it can be to provide information and tools to those on the frontlines of medical care, that approach wrongly implies that a *lack* of education is what leads to errors in the first place.

"You can't teach your way to safety," Dr. Gleason says. "Safety must be built." The focus needs to be on working with people who are already driven to be excellent to improve the systems that may facilitate or even lead to mistakes.

Carilion has developed a Four Pillars Model for meaningful improvement: safety culture, analytics, process improvement, and human factors.

"We rely on engaged staff to identify opportunities and participate in change," Dr. Gleason says. "We use analytics to understand our opportunities, performance improvement to redesign care, and human factors and simulation to ensure that our care redesign will result in the desired outcome when applied to patients in the environment of care."

This approach was recognized by the Next Generation Innovator program at the prestigious National Quality Forum in March 2018. Carilion is the only health system to have been recognized with this honor.

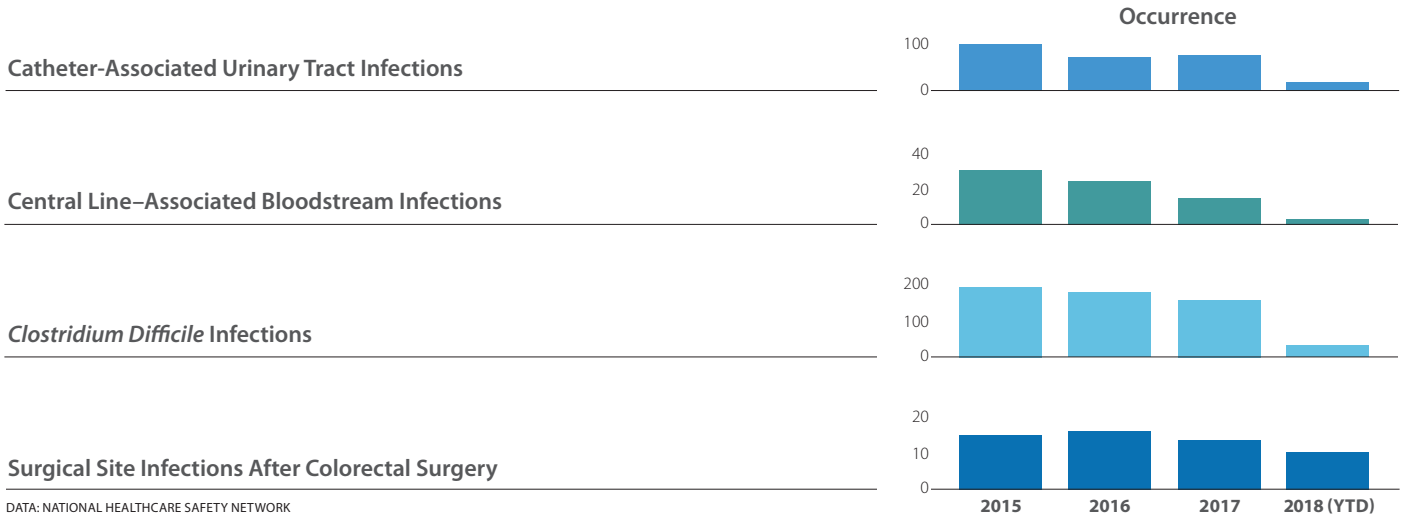
"Modern health care is a complex human–machine interaction," Dr. Gleason says. "This gives us the opportunity to build a clinical operating system that is more likely to achieve the results we seek. We use behavioral economics, process improvement, and human factors design to build better and safer health care."

That approach may involve redesigning a test-ordering protocol to reduce infection rates and overtreatment, using artificial intelligence to better identify patients who are at risk for being readmitted to the hospital, or systematizing a method for conversations about end-of-life care.

"At Carilion, CAPS has taken on a life of its own," says Dr. Gleason. "For all of us, this is about starting by saying we're really good at what we do. Now, let's be exceptional. And let's bring together all of the resources we have to make that happen. Together, we have to build safety. We're fortunate to have considerable resources in quality, analytics, process improvement, human factors, and our new Center for Simulation, Research and Patient Safety."

THE NUMBERS ARE DROPPING

Carilion Clinic's aggressive push to limit harm of any kind continues to bear fruit



DATA: NATIONAL HEALTHCARE SAFETY NETWORK

Gleason

the gift of the NEAR MISS

Carilion Clinic's interventional radiology group is trained in both radiology and interventional therapy, two fields that have come together as doctors combine imaging and minimally invasive tools to diagnose and treat patients. In 2017, when performing CT-guided procedures, this group experienced a series of near misses. No patients were hurt, but the potential for harm had been real.

"One of the greatest gifts we get in medicine is a near miss," says Patrice M. Weiss, M.D., Carilion's chief medical officer and executive vice president. "How we respond to it defines our organizational culture."

In keeping with the culture of learning and understanding rather than blaming, the near misses—reported through SafeWatch, Carilion's event-reporting software—were seen as an opportunity. Joseph Hughes, M.D., and Leslie Hall, R.T.R., the team responsible for responding to issues noted in SafeWatch, recognized a trend that called for a system response. Closer analysis revealed that the error rate during the complex ordering process for certain procedures was 66 percent. "This problem never resulted in harm," Hall says, "because we have excellent staff who were diligent in identifying any problems in the ordering process."

Working together, the quality leader, the human factors and process improvement teams, and the interventional radiology department redesigned the process for ordering the tests. In a matter of weeks, the error rate dropped from 66 percent to 1 percent.

"This case illustrates our Four Pillars Model at work," says Jonathan Gleason, M.D., vice president of clinical advancement and patient safety. "These factors—safety culture, analytics, process improvement, and human factors—seek to achieve safe and reliable health care."

PHOTO: JARED LADIA

> **"This isn't only about doing the right thing for the people we help. It's also about mitigating further risk."**
>
> —NEELY CONNER, L.C.S.W., PRACTICE MANAGER FOR CARILION EMPLOYEE ASSISTANCE

One Carilion priority—improving diagnostic stewardship—involves managing the high rate of medical testing. The goal isn't necessarily to do fewer tests but to identify the *right* tests.

"It's about being very deliberate and systematic about how we use certain diagnostic tests," Dr. Gleason says, "and creating mechanisms to help our system right-size our testing."

Testing for *Clostridium difficile*, known as *C. diff*, shows how that can be done. Diagnostic issues arise when patients who test positive for *C. diff* do not actually have an infection, but are colonized with the bacterium. Changes that were made to the ordering process and the lab dramatically reduced testing and overtreatment of *C. diff*. Similar adjustments in other areas have also promoted diagnostic stewardship.

Helping Second Victims

When a medical episode involves inadvertent error or simply has a poor outcome, the primary concern is always for the patient—the first victim. But recent research underscores the damage that "second victims"—the medical personnel involved—may also suffer. At Carilion, the TRUST Team focuses on helping those second victims, who may experience emotional and physical symptoms.

TRUST stands for "**T**reatment that is just, **R**espect, **U**nderstanding and compassion, **S**upportive care, and **T**ransparency and opportunity to contribute." The TRUST Team's principal goal is twofold—to identify second victims who may need support and counseling, and then to provide that support, including from colleagues who may have been in similar situations, as well as from mental health professionals and other health care experts.

During its first two years, the TRUST Team received only a handful of referrals of second victims. Since then, the team has focused on developing systemwide communication about the second victim phenomenon and the TRUST Team, as well as creating referral mechanisms to help ensure that all care providers experiencing distress related to an adverse patient event receive support.

In April 2017, the team began using SafeWatch, Carilion's electronic event-reporting software, which tracks "events" that might involve second victims, to trigger referrals. That led to 112 referrals that year, and another 63 in 2018 through mid-March.

PHOTOS, THIS SPREAD: JARED LADIA

"To our knowledge, we are the only health system that has built a mechanism for provider support directly into the event-reporting system," says Dr. Gleason. "For literally every reported event that occurs in our health system, we have forced ourselves to ask a question: Does this provider need support?"

The TRUST Team reaches out to each second victim by phone or email just to ask how the person is doing.

"Everyone gets some kind of contact," says Neely Conner, L.C.S.W., the practice manager for Carilion Employee Assistance. "In working with those second victims, we look at sleep, appetite, support systems, concentration, and focus. We're probing for symptoms of acute distress. Based on that assessment, we may recommend additional support.

"This isn't only about doing the right thing for the people we help," Conner adds. "It's also about mitigating further risk."

Working with a clinician who has been involved in a medical error or adverse event can help relieve stress or other problems that could affect patient care. It's all part of developing what Conner calls "a culture of safety and compassion and respect."

The response of one doctor, who had undergone a particularly harrowing experience, has stuck with Conner.

"She was very, very seasoned and had served in capacities that certainly weren't a walk in the park," Conner says. "When we got in touch with her, she was so grateful. She said, 'No one has ever cared enough to reach out and check on me after an event.' I think that will stay with me for a while."

Finding Answers on the Frontlines

In the quest to avoid mistakes, improve care, and enhance patient safety, frontline care providers are in an ideal position to notice potential problems and suggest solutions. One grant-funded nursing research study, for example, looked at the pneumococcal immunization rate for at-risk adults visiting walk-in clinics. The research led to changes that almost doubled the percentage of patients receiving the vaccination, from 32 percent to 56.8 percent, thus reducing their risk for the serious health effects of pneumococcal pneumonia.

The Nursing Research Fellowship, run by Kimberly Carter, R.N., Ph.D., senior director of nursing research and evidence-based practice, also capitalizes on nurses' frontline perspective, offering them support in designing, implementing, and disseminating studies that move swiftly from question to research to action.

To qualify for the yearlong program, nurses must have well-developed ideas grounded in literature reviews, as well as methodologies for testing their hypotheses. Those who are chosen receive the support of a mentor, take relevant classes, and can take time off from patient care to complete the work.

Many studies in the fellowship program have already had a direct outcome on patient care. One initiative compared bras for female patients who have undergone a sternotomy, in which the sternum is "cracked" open during surgery. Without proper breast support during recovery, women face several postoperative complications. So, after surgery, patients must wear a supportive bra for 20 to 24 hours a day. Before the study, the only bra that nurses had available for patients was a hook-loop front closure. "Frontline nurses questioned whether this was the best bra," says Dr. Carter.

"Our ultimate goal is to provide our patients with the highest quality care each and every day. That means we can't just do things the way we were taught in school."

—KIMBERLY CARTER, R.N., PH.D., SENIOR DIRECTOR OF NURSING RESEARCH AND EVIDENCE-BASED PRACTICE, CARILION CLINIC

So Kimberly Bolling, R.N., and Takako Long, R.N., both at Carilion Roanoke Memorial Hospital, designed a study to compare options. They found that the hook-loop front closure of the standard-of-care bra led to irritation and rubbing, and some patients simply stopped wearing the bra. The study, which compared that bra with two others, discovered a strong preference among postop patients for a more comfortable bra with a hook-eye closure. They wore it more consistently and reported greater satisfaction.

"The result of this study led to a practice change, and patients undergoing a sternotomy now have the evidence-based bra put on right in the operating room," says Dr. Carter.

Dr. Carter believes that the fellowship program both leads to changes that benefit patients and fosters a culture of excellence and curiosity that is essential for a thriving, dynamic staff. Giving nurses the support to lead their own research projects offers yet another way to achieve a higher level of patient care.

"Our ultimate goal is to provide our patients with the highest quality care each and every day," Dr. Carter says. "That means we can't just do things the way we were taught in school. Patient needs, nursing practices, and the resources available are always changing. It's essential to keep asking whether we're doing something a particular way because that's what we were taught, or because it's the best way to help patients."

As the broader health care community continues to pursue improvements in patient care and safety, Carilion aims to go further, using every means at its disposal—dedicated staff, research, technology, data, and support systems.

"We do have an outrageous goal to be the global leader in quality and patient safety," says Dr. Gleason. "I think we're well on our way. And we're going to get there." CM

A team of experts at Carilion Clinic is researching perfection in health care—and implementing findings in real time. BY CHARLES SLACK

the human factor

IT'S LATE AT NIGHT IN THE CARDIAC CARE UNIT OF A BUSY hospital. A cardiologist asks the on-duty nurse to administer heparin, a common blood thinner, to a patient at risk for clotting. Nearing the end of a long shift, the nurse retrieves a vial from a drawer in the medicine cart and, despite checking the label, mistakenly prepares to administer not heparin but a potentially harmful dose of lidocaine, a local anesthetic.

What might first appear a clear and unambiguous case of nurse error is actually something more complex. The nurse entered the proper information into the cart's computerized screen and pulled the medicine from the drawer where the heparin is always stocked. Although she checked the label, the nurse saw what she expected to see: heparin, not lidocaine. Did a colleague also err by stocking drawers with the wrong medicines? And while he could have been more careful, did the workers who packed the medicines for the pharmacy err by mislabeling the boxes they came in?

Other questions arise: Were the containers of heparin and lidocaine shaped too similarly? Could larger fonts or bolder colors on the labels help distinguish one drug from another? Could the computerized carts be designed and programmed to better detect and prevent mix-ups?

PHOTO: DAVID HUNGATE

TEAM SPIRIT: Dr. Bryan Collier (top right), chief of trauma surgery at Carilion Roanoke Memorial Hospital, performs a tracheostomy. Carilion's human factors experts study the high stakes of teamwork in surgical suites.

Considering the hectic, always-on environment of the 21st century, U.S. hospitals are, by and large, marvels of efficiency. Yet mistakes happen, and in an industry where lives are at stake, preventable errors are unacceptable. And, as this hypothetical case illustrates, the problem often reflects not one large error but a series of smaller ones that might have been prevented through improvements in processes, training, or equipment. The nurse administering the wrong medication is at the tip of a much larger iceberg of issues hidden beneath the surface. Following these many and multifaceted trails to identify trouble spots and recommend solutions is the province of an emerging health care field known as human factors.

"Nobody, particularly health care workers, comes to work *not* to do their best," says Sarah Henrickson Parker, Ph.D., senior director of Carilion Clinic's Center for Simulation, Research and Patient Safety and a research assistant professor at the Virginia Tech Carilion Research Institute. "The clinicians and staff we work with on a daily basis are just incredible."

A human factors approach, then, is not about pointing fingers or finding fault with specific workers, she adds. Rather, it's about understanding human capabilities and limitations and designing processes that "make it easier to do the right thing, and harder—ideally impossible—to do the wrong thing."

Carilion Takes a Lead Role

Carilion has emerged as one of a few health care systems nationally with a dedicated human factors team led by doctoral-level scientists. These experts oversee studies into how processes, equipment, and environments can better accommodate the ways that workers under stress think and react to rapidly changing events.

Launched just over two years ago, Carilion's human factors initiative is already having a tangible impact. By helping clinicians improve placement and care of catheters and become more deliberate and tactical in the use of antibiotics, for example, the team has helped Carilion reduce hospital-acquired infections.

The human factors team is one part of Carilion's overall commitment to advancing patient safety and improving the already high standards of care across the system's seven hospitals and 13,000 employees. Jonathan Gleason, M.D., who oversees these efforts as vice president of clinical advancement and patient safety, describes them as fully collaborative pursuits.

"The goal is for all of us to get better," Dr. Gleason says. "Process improvements start with forming strong relationships with staff and building on the idea that we're really good, but we can be better. That's something everyone can get behind."

Origins of Human Factors

The study of human factors as a distinct field, though relatively new to medicine, goes back decades in other high-stress, high-stakes industries. In aviation, for example, human factors research has led to such improvements as better communication between pilots and crews, enhanced systems to guard against human error, and more ergonomically designed cockpit instruments.

Safely flying a civilian jetliner to its destination and completing a successful mission at the controls of an advanced military helicopter are undeniably complicated tasks requiring precise use of instruments, multiple decisions, and accurate communication. Yet health care adds even more levels of complexity, Dr. Parker says. Unlike the confined environment of a cockpit containing a finite number of crew, a hospital is essentially a small city where hun-

DREAM TEAM: Dr. Sarah Henrickson Parker (left) and Dr. Laurie Wolf

> **Human factors research is not about pointing fingers; it's about understanding human capabilities and limitations and designing processes that make it easier to do the right thing.**
>
> — SARAH HENRICKSON PARKER, PH.D., SENIOR DIRECTOR OF THE CENTER FOR SIMULATION, RESEARCH AND PATIENT SAFETY AT CARILION CLINIC

PHOTOS, THIS SPREAD: JARED LADIA

> **"We're helping our caregivers have the right tools, the right decisions, and the right filters in place so they can be in that direct patient care role more effectively."**
>
> — MATTHEW JESSO, HUMAN FACTORS SPECIALIST AT CARILION CLINIC

dreds or thousands of employees perform countless daily tasks, each of which may affect a patient's safety or comfort.

"You're not only asked to use your skills and training as a nurse or physician, you're also asked to be engaged, one human to another," Dr. Parker adds. "This is about people taking care of people."

Laurie Wolf, Ph.D., director of human factors implementation, joined Carilion last October. She had started her career in ergonomics more than 20 years ago, helping design safer interiors for automobiles and ergonomic control panels for military helicopters and tanks.

In health care, Dr. Wolf says, human factors work was originally about reducing accidents in order to limit workers' compensation. In the last decade or so, the trend has shifted increasingly to a focus on patient safety.

Dr. Wolf adds that she was attracted to Carilion not only by its clear commitment to researching human factors and devising ways to apply those findings to improve care, but also by the open culture and eagerness on the part of clinicians and others to identify improvements.

"I've been impressed with the dedication and expertise of people here, and their willingness to share without defensiveness," she says. "People really take this to heart."

Laying the Fundamentals

A centerpiece of the efforts is the Parker Lab, which operates as part of both Carilion and the Virginia Tech Carilion Research Institute. The lab is devoted to ongoing research into how workers behave and respond in stressful situations requiring quick decisions, multitasking, and teamwork. Some projects are aimed at contributing to our basic understanding of human behavior.

The research combines elements of computational modeling, organizational psychology, and observation of individuals and teams in highly realistic simulated situations in Carilion's new Center for Simulation, Research and Patient Safety.

In one study funded by the Agency for Healthcare Research and Quality, for example, doctoral candidates at the Virginia Tech Carilion Research Institute are researching whether brief, periodic pauses can help health care workers maintain peak efficiency. Subjects perform simulated yet stressful tasks. Some are instructed to stop and take a deep breath—to "reset the brain," as Dr. Parker puts it—at moments of peak stress. Others pause at random intervals, while still others take no breaks. Understanding which approach results in the best performance could one day help clinicians in a trauma situation or operating room stay at their sharpest during the most demanding procedures.

Another study investigates the extent to which surgical teams benefit from prior experience working together. While logic dictates that well-oiled teamwork helps any endeavor, the researchers are mining Carilion's vast database of process metrics (such as room turnover time) and outcomes (such as duration of surgery and length of stay) from past procedures to examine which specific pairings of operating-room team members—such as surgeon and scrubber, or surgeon and circulator—and which types of procedures—whether knee replacement or heart surgery—gain the most when staff members have familiarity with one another.

The idea, Dr. Parker says, is not to evaluate individuals; in fact, in all studies, clinicians are completely anonymized. Instead, the goal is to gain a deeper understanding that could one day help Carilion and other health care systems deploy staff more effectively and with better results for patients.

Found in Translation

As those long-term studies produce findings that may pay dividends down the road, the Carilion team is finding ways to improve procedures in real time.

"Carilion is unique in its dedication to *translational* human factors," says Dr. Wolf. "What I mean by that is taking concepts

> **"We're learning more and more how to take care of patients in ways that are better and safer than before. Many great advances are coming for our patients."**
>
> — DANIEL HARRINGTON, M.D., VICE DEAN, VIRGINIA TECH CARILION SCHOOL OF MEDICINE

from academic studies or laboratories and putting them into an actual hospital setting—bringing them alive, in the real world." As director of human factors implementation, Dr. Wolf is tasked with evaluating processes at Carilion and working with individual departments on possible improvements.

As one example, Dr. Wolf and Matthew Jesso, a human factors specialist, have been observing Carilion workers such as nurses and emergency vehicle dispatchers whose jobs include tracking information on multiple computer screens. Dr. Wolf and Jesso are working on recommendations that could help streamline the information and potentially reduce the number of monitors.

"We're helping our caregivers have the right tools, the right decisions, and the right filters in place," says Jesso, "so they can be in that direct patient care role more effectively."

Sometimes, reducing the possibility of error involves something as seemingly straightforward as revising a form. In one instance, hospital staff members were having trouble transcribing information provided by outpatient clinics that referred patients to Carilion for treatments. Jesso worked closely with Carilion's process improvement experts to better understand the problem and develop interventions.

"Each clinic had its own forms, so Carilion staff could be looking for specific information in the top right or in the middle of a form, or find it buried in tiny text, or on the third page of a document," Jesso says. "The information wasn't presented in a standardized way."

Beyond straining already busy workers, the process escalated the possibility of errors or omissions. The solution? A standard, one-page cover sheet containing essential information in easily identifiable locations.

Also key are usability studies, which allow the human factors team to evaluate new technologies and equipment under consideration to help ensure they work well with existing systems and hospital workers won't find them burdensome to use. Although a new defibrillator may be a wonder of engineering, if a nurse who does not often use the machine misunderstands the indicators on the control panel and accidentally turns the machine off at the wrong time, the impact on a patient in distress could be disastrous.

By watching teams test equipment under simulated situations such as this, Dr. Parker says, "We're getting closer to the context in which work is actually done."

Educating the Next Generation

With the human factors field evolving so rapidly, specialists such as Dr. Parker believe its greatest payoffs lie ahead. At the Virginia Tech Carilion School of Medicine, human factors and patient safety are increasingly part of the curriculum. Rather than teaching human factors as a separate course, Dr. Parker says, the school is incorporating new ideas about teamwork and better communication with other clinicians and patients into everything the medical students learn.

That's an idea that fits perfectly with the school's innovative, case-based teaching method, says Daniel Harrington, M.D., the school's vice dean. Instead of focusing just on basic science during the first two years, as students at many medical schools do, Virginia Tech Carilion students delve deeply into patient cases and then teach their peers what they've learned. Increasingly, issues of safety and human factors inform those discussions.

"After hearing about quality and safety, students are able to go home and do investigations on their own, and then come back and teach their classmates," says Dr. Harrington, a psychiatrist at Carilion, where he also serves as vice president for academic affairs. "When the students enter the clinical phase of their education, their clerkships have stated goals and objectives about quality and safety."

As today's students become tomorrow's clinicians, Dr. Harrington adds, "We're learning more and more how to take care of patients in ways that are better and safer than before. Many great advances are coming for Carilion and, most important, for our patients." CM

PHOTOS, THIS SPREAD: JARED LADIA

in the SIM LAB

practice pursues perfect

When a patient suffers a cardiac arrest, it requires fast action by clinicians trained for such an emergency. Although cardiac arrests are most often seen in the emergency department and intensive care units, they can occur anywhere in the hospital.

Therein lies a challenge: How can Carilion Clinic help ensure that physicians and nurses in other units, where heart attacks are relatively rare, are also fully prepared to help a patient in need? Enter Carilion's new Center for Simulation, Research and Patient Safety—also known as the Sim Lab—which enables clinicians to "revive" sophisticated mannequins in a highly realistic setting.

Mannequins are more than just patient proxies; they are advanced computers that can blink, breathe, move, and even mimic appropriate physiological responses to clinical interventions. They can also present a range of clinical conditions.

"Repeated practice on these mannequins has really improved how a range of clinicians respond to cardiac arrests," says Timothy Fortuna, D.O., the Sim Lab's medical director.

Centrally located in a historic Roanoke building known as the Trolley Barn, which once housed streetcars undergoing repairs, the 12,000-square-foot Sim Lab features four advanced simulation rooms—including a trauma bay, an operating room, and two patient rooms. And mannequins, while virtually synonymous with simulation, are just the start.

Computer rooms, a skills lab, and debrief rooms complete a holistic facility capable of reproducing just about any hospital situation. The center, which opened in February, replaced the previous 800-square-foot lab.

"Before, we had essentially one room to work out of," Dr. Fortuna says. "Now we have four. In one room we can be teaching residents. In another we can be teaching medical students, and, in still another, nurses."

The Sim Lab provides a dual benefit of training medical teams for their current jobs and helping Carilion's human factors specialists learn by watching them. In addition to basic research into how medical workers function in their stressful tasks, the human factors team, led by Sarah Henrickson Parker, Ph.D., uses the Sim Lab to test technologies.

"While technologies are great, they're not always designed for frontline caregivers' use," says Dr. Parker, who serves as senior director of the Sim Lab. "To have the best technology in place, we have to understand both its capabilities and the context in which it is being used."

Simulation is increasingly critical in training medical students and residents, says Daniel Harrington, M.D., vice dean of the Virginia Tech Carilion School of Medicine. "In years past, students and residents learned how to do procedures such as starting IVs or placing central lines by doing on them on patients," he says. "Now they learn through simulation."

And in the Sim Lab, the learning doesn't stop with students and residents. Experienced surgeons prepare for situations they hope they'll never see, such as a nicked artery that could result in potentially fatal bleeding.

"It's not something that happens often, thankfully, but if it does, it's a very high-risk event, and you want to be proficient in it," Dr. Fortuna says. "In the Sim Lab, we can reproduce those scenarios at any time."

CarilionClinic.org/carilionmedicine

THEY'RE NO DUMMIES: Carilion's new simulation center offers a range of learning opportunities from advanced mannequins, including a female whose abdomen adjusts to different birthing scenarios (top left) and a male programmable for multiple medical emergencies (above).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The Virginia Tech Carilion School of Medicine's standardized patient program employs masters of deception to help medical students sharpen their clinical skills. **BY CATHERINE DOSS** PHOTOS BY JARED LADIA

playing the patient

AFTER A QUICK KNOCK ON THE DOOR, A WHITE-COATED YOUNG WOMAN enters the room. "Good afternoon, Ms. Waters," she says. "My name is Lisa Crisalli, and I'll be taking care of you. What's brought you in today?"

It sounds like the start of a typical doctor's appointment, but instead it's a central component of the clinical training students receive at the Virginia Tech Carilion School of Medicine.

The medical school has 10 identical rooms, each set up like a typical exam room at a doctor's office. Yet if you look up, you'll notice two cameras mounted on the walls. The rooms are where medical students learn how to conduct clinical exams, and the cameras provide a means for evaluating their patient encounters.

Students have on average one required standardized patient encounter every week through the first two years of school, with other opportunities for practice sessions and further training in years three and four.

"Our program is longitudinal," says Heidi Lane, Ed.D., senior director for clinical skills assessment and education at the medical school. "We try to correlate the simulated medical conditions with what students are studying elsewhere in the curriculum at any given time."

the stage

The Virginia Tech Carilion School of Medicine has 10 fully equipped examination rooms in which medical students can practice their skills on standardized patients in a controlled, risk-free environment.

Tarin Schmidt-Dalton, M.D., associate dean for clinical science years 1 and 2, says integration of the school's standardized patient program into its curriculum blocks provides a powerful learning tool.

"Early exposure to patient scenarios is critical for developing effective, patient-centered communication and physical examination skills," she says. "It also helps students integrate content from the basic science disciplines, such as physiology and anatomy, and apply their knowledge in a fun, clinically engaging environment."

Although most medical schools have a standardized patient program, Dr. Lane says the program at the Virginia Tech Carilion School of Medicine is one of the most comprehensive.

In addition to the usual cadre of standardized patients are ones who have been certified as physical teaching associates by undertaking additional intensive physical exam training based on the guidelines from which the students themselves learn. After mastering the art of teaching physical exam methods, these associates teach, assess, and give feedback on details such as the exact spot to palpate and the correct amount of pressure to use. Their work allows faculty members to teach the implications of findings and special types of physical exam maneuvers. It's a winning solution for all.

Dr. Lane's program employs a tightknit group of dedicated professionals who embody the concept of quality assurance in everything they do. In addition to regular encounters, students are offered practice times with standardized patients and physical teaching associates. Video recordings of patient encounters are painstakingly reviewed, and feedback and remediation are offered. In addition, standardized patients are active in giving feedback.

Crisalli, a member of the school's class of 2020, says standardized patients help students improve their clinical technique, especially with minor yet critical adjustments that might be difficult to coach on the clinical units.

the actors

Standardized patients help medical students learn to think critically. The "patients" begin with a back story—a complete medical history—and a script. They also learn how to move their body like a patient with their assigned complaint would and how to react to the physical examination in character. Left: First-year student Ryan Perry performs an exam on standardized patient Linda Dane. Below: A medical student performs an eye exam on standardized patient Jeff Edwards, while student Dixon Lee watches.

"The feedback from standardized patients is one of the best parts of the program," she says. "They act not only as convincing patients, but also as educators, providing insights into process and technique. They are attentive, encouraging practice of a skill until it is perfected."

Students thrive on the training, practice, and evaluation. Beginning with its first class, the school has an unbroken record of a 100-percent pass rate on the USMLE Step 2 Clinical Skills exam.

Zakk Walterschied, a member of the class of 2018, recalls the moment that made him realize what an important part of his education standardized patients had been. "When I went for my Step 2 exam, I saw medical students who had never worked with a standardized patient before," he says. "That was so foreign to me. Our Fridays consisted of working with standardized patients."

"We are teaching our students how to think critically," Dr. Lane says. "By the

end of a physical exam, they need to be able to say, 'This is what I know from the exam, this is what I don't know, and this is what I need to know to rule out or confirm diagnosis.'"

Dr. Lane added that even though students learn theoretical underpinnings in lecture sessions, applying those principles to a real person can be different.

"They may know how to do a physical exam when they're practicing with a friend, but when they get someone they don't know, and they have to think on their feet, sometimes it just flies out of their head," she says. "This is why we're here to evaluate how they did and offer help if they need it."

The Virginia Tech Carilion School of Medicine's standardized patient program is also unique in its close involvement with the school's interprofessional curriculum. Interprofessionalism—one of the school's four value domains, along with basic science, clinical science, and research—emphasizes service learning and team-building activities that involve medical students and students in a range of academic programs at Jefferson College of Health Sciences—including nursing, physician assistant, respiratory therapy, emergency services, and public health.

One highlight each spring is a daylong disaster training drill that uses standardized patients in intense, high-energy scenarios. During the drill, the students have to work as a team to treat the patients, who offer real challenges in real time, such as unrecognized internal bleeding.

The methodology of using standardized patients began about 40 years ago as a means to counteract the difficulty of acquiring real patients who had the type of medical issues a student needed to learn at any given time. With standardized patients, every student is able to learn the same medical condition that is consistently portrayed.

"A standardized patient program allows students to make mistakes in a safe environment," Dr. Lane says. "They can ask questions and perform physical exam maneuvers incorrectly without their faculty member watching them."

Dr. Lane is internationally known for her expertise in establishing and managing standardized patient programs. She arrived at Virginia Tech Carilion with an impressive breadth of experience as a senior standardized patient trainer. She was actively involved on the task force for standardized patients with the National Board of Medical Examiners to set up training and implementation protocols as they were developing the USMLE Step 2 exam.

In 2013, Dr. Lane was recognized by Kazan State Medical University in Russia for her work developing a standardized patient program as part of that school's curriculum. Established in 2000 by Dr. Lane and Beth

behind the scenes

The examination rooms at the Virginia Tech Carilion School of Medicine allow live monitoring of student encounters with standardized patients, as well as recordings of sessions, to allow students to perfect their interactions. Clockwise from top: In the nerve center, Elizabeth Briere, left, standardized patient trainer, and Taylor Lynch, clinical skills manager, watch and take evaluation notes on a clinical encounter; Sharita Brown, left, clinical skills coordinator, demonstrates proper palpation technique for Jeff Edwards, physical teaching associate, on standardized patient Linda Dane; and, from left, medical students Morgan Julian, Dixon Lee, and Keri Godbe practice clinical skills on a standardized patient.

Ipock, MA.Ed., M.S.W., director of clinical skills assessment and education, with administrators at Kazan, it was the first such program at any Russian medical school. The partnership quickly evolved into an international rotation exchange program between the Virginia Tech Carilion School of Medicine and its Russian counterpart.

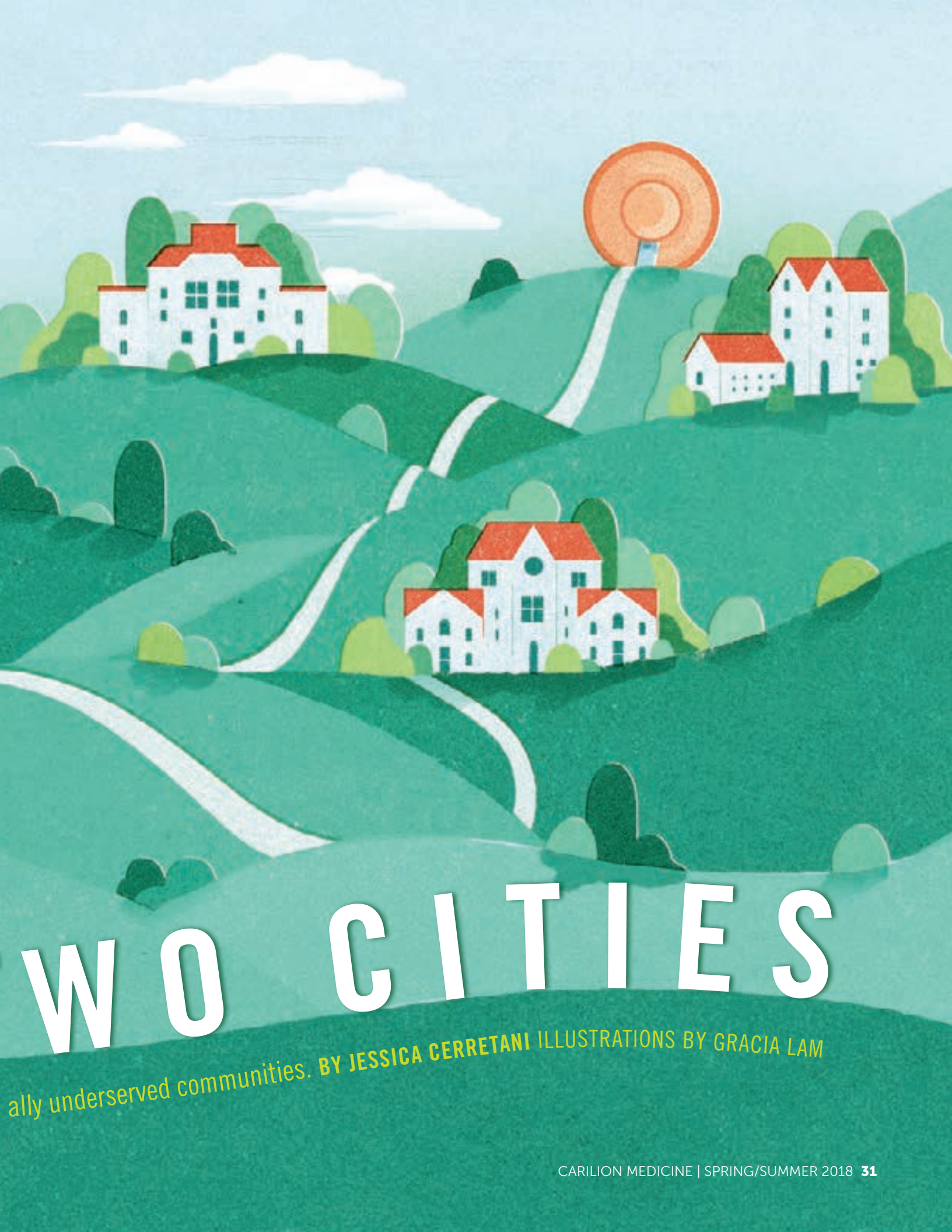
Dr. Lane says many of the school's standardized patients play the part as a way to give back because they appreciate the local medical community.

Others, like Linda Waters, who has been in the role for seven years, want to remain busy and active. After 35 years working as a physical therapist, she says she finds the job the perfect post-retirement solution.

"I love being in a medical environment, and I love being around young people who are striving to become good doctors," she says. "It's interesting, mentally stimulating, and fun. And I feel like I'm an ambassador for the medical school." CM

A TALE OF T

Carilion reaches beyond clinic walls to partner with local organizations in helping medic



WO CITIES

ally underserved communities. **BY JESSICA CERRETANI** ILLUSTRATIONS BY GRACIA LAM

At the top of Mill Mountain, the illuminated Roanoke Star casts a bright neon gleam over the city below. Although the icon has overlooked Roanoke City for nearly 70 years, these days, the glow seems a little more auspicious—especially to those who are working hard to ensure that the area's residents have the same opportunities for good health as their neighbors.

Despite their proximity, Roanoke City and Roanoke County have vastly different characteristics. As recently as 2015, the former was listed at 123 out of 133 in the Robert Wood Johnson Foundation's annual health rankings for the state of Virginia. Yet Roanoke County was considered one of the healthier areas with a rank of 12.

It's a discrepancy that doesn't sit well with the Carilion Clinic community, says Shirley Holland, vice president of planning and community development at Carilion.

"These two areas border each other," she explains. "Within the shadow of our largest hospital, we have a zip code where almost 40 percent of residents live below the federal poverty level, in what's deemed a 'medically underserved area.' Are we okay with that?"

The answer, it turns out, is "no"—and that refusal to accept such health disparities as normal has led Carilion to look beyond its walls, reaching out to the surrounding communities.

"The acute care we provide—in the hospital, in the emergency department, in urgent care centers—is and will continue to be important," says Holland. "But is it enough?"

Beyond Clinical Care

It's clear that clinical care is just one of many factors that determine good health. Indeed, elements such as income, education, neighborhood safety, and access to food and stable housing have a strong influence on overall health and life expectancy.

According to one meta-analysis of nearly 50 studies, social determinants of health account for about one-third of total deaths in the United States each year. The difference between longevity and premature death can stem from problems as diverse as a lack of transportation to medical appointments, a dearth of safe walking areas in neighborhoods, and limited access to fresh, wholesome food.

A 5-percent reduction in the incidence of hypertension—through lifestyle measures such as decreasing dietary sodium—could save the country an estimated $25 billion in five years.

Prevention plays a key role, too. Recent statistics from the U.S. Surgeon General underscore the impact of taking a proactive approach to health, on both quality of life and health expenditures: For instance, just a 5-percent reduction in the incidence of hypertension—through lifestyle measures such as decreasing dietary sodium—could save the country an estimated $25 billion in five years. Likewise, increasing physical activity has been shown to reduce the risk of developing type 2 diabetes by 58 percent, potentially leading to tremendous savings in a country where one of every five health care dollars is spent on diabetes care.

"We're increasingly recognizing that many different factors contribute to health," says Holland. "It's time for us to invest more in our communities—in prevention and wellness—so we're addressing these factors long before people come to the hospital."

A PRESCRIPTION FOR CHANGE

It's something most of us take for granted, whether we're simply relying on it for fuel or enjoying a delicious meal. Yet for many people, accessing fresh, wholesome food is an everyday struggle. According to some estimates, more than 1.7 million Virginians live in food deserts, areas where residents tend to have low incomes, lack transportation, and live more than one mile away from a supermarket. With poor access to good food, families may rely on convenience-store and fast-food offerings, which can contribute to obesity, diabetes, and other chronic conditions.

To help improve Roanoke's diet, Carilion Clinic, in partnership with Healthy Roanoke Valley, offers its Fresh Foods Rx program in two locations. The program targets overweight and obese adults at risk for diabetes and includes weekly health education classes as well as prescriptions and cash vouchers to buy fresh food at the practices' weekly mobile markets.

So far, the results are promising: More than 60 percent of participants have decreased their body-mass index and hemoglobin A1C measures, while half have lowered their blood pressure.

Inspired Solutions

With so many intertwining aspects of health, a multipronged approach is necessary, says Kimberly Dunsmore, M.D., Carilion's chair of pediatrics.

"No one institution can fix very complex issues like these," she explains. "The really lovely thing about Roanoke is that the population is so diverse—we look like America—and Carilion can leverage many different resources that allow us all to work together for innovative change."

One such example involves the deployment of community health workers to Southeast and Northwest Roanoke, which are designated as medically underserved areas. In partnership with Healthy Roanoke Valley, a community coalition housed under United Way, Carilion helps place these specially trained professionals, who encourage patients to advocate for their health and wellness. That can mean helping patients get insurance or job training, finding transportation to medical appointments, or connecting them with primary care providers to cut down on emergency room visits, for instance.

The Virginia Health Care Foundation funded an 18-month pilot study of this coordination-of-care program, and the results suggest that its impact can be significant. Of the 245 patients served, emergency room visits decreased by more than 60 percent, while charity care costs dropped by about $500,000. Based on these promising outcomes, says Holland, the program plans to expand to include additional community health workers.

A similar strategy is in the works to bring preventive care to children and families in the Roanoke City school system. While Carilion already provides nurses to these schools, their current role is largely limited to caring for kids with acute conditions, such as a stomachache or fever. Holland and Dr. Dunsmore have a much broader vision: They hope to establish schools as wellness hubs, where students and their families have access to a variety of resources, such as routine health screenings, immunizations, and even chronic disease management.

"We see this as an opportunity to reinvent school nursing programs," says Dr. Dunsmore.

Increasing physical activity has been shown to reduce the risk of developing type 2 diabetes by 58 percent, potentially leading to tremendous savings nationally.

Although the proposed program is still in the early planning stages, supporters are optimistic that Carilion and other potential partners will support its creation. By tackling diseases that start in childhood, they hope to stem the tide of chronic conditions affecting Roanoke adults. Dr. Dunsmore envisions, for instance, regular screening programs for respiratory health and blood pressure, which might help ward off emergency room visits for asthma attacks and future cardiovascular disease.

"We've been asked by the Roanoke City school system to have a more vibrant interaction with them," Dr. Dunsmore explains. "We see this idea as an opportunity to provide kids with proactive interventions before they become ill."

Collaboration and Coordination

Other initiatives are aimed at addressing issues such as substance abuse, which can also have an impact on physical health. In 2016, the governor's office declared the Virginia opioid addiction crisis a public health emergency. For Carilion, the crisis has hit close to home: About 15 percent of Roanoke City's population has admitted to recent heroin use, and southwestern Virginia has the state's highest overdose mortality rates.

That grim scenario has spurred Carilion's leadership to assemble a comprehensive Opioid Task Force to confront opioid abuse from multiple angles. Clinicians and other experts from specialties as diverse as emergency medicine, pain, psychiatry, research, information technology, and public policy are banding together to provide an organized response to the epidemic.

"Carilion had already been doing a lot of good work in this area, yet the groups involved weren't necessarily approaching it in a coordinated way,"

says Robert Trestman, M.D., Ph.D., chair of psychiatry and behavioral medicine at Carilion and co-chair of the task force. "As clinicians, we've unwittingly contributed to the problem by overprescribing these drugs. Now we believe it's partly our responsibility to help solve it."

On the task force's agenda: creating a multidisciplinary approach to pain management, using electronic health records to guide prescribing practices, educating patients and providers about the problem, and embarking on research into innovative approaches to addiction. Over time, Dr. Trestman explains, residents struggling with opioid dependency can begin to expect better integration of medical management and psychotherapy and improved access to social support agencies.

"We need to help them get through their immediate challenges," he says. "Then there's a lot of hope for people."

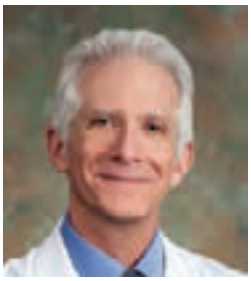
Signs of Progress

Today, there's also change in the air: The Robert Wood Johnson Foundation's health rankings for 2018 place Roanoke City further up the list at 112. It's a slow yet promising climb: "It took decades for us to get here, and it's going to be a long road out," admits Dr. Dunsmore. "But these small improvements speak to the progress being made."

She's hopeful that the future holds even more good news for Roanoke patients, as long as Carilion continues to collaborate within and outside its walls. "Solving such a complex set of problems requires different skill sets, from medicine to community development to government," she says. "In this case, it doesn't just take a village to effect change—it takes a city, and the Star City is the perfect place to do that."

Holland agrees. "We're learning how important real partnerships are," she says. "We can't just go into the community and change people's health. It has to be a collaborative effort. It takes everyone together to make a difference—and that starts with each one of us." CM

EXPERT INSIGHTS



"As clinicians, we've unwittingly contributed to the problem by overprescribing these drugs. Now we believe that it's partly our responsibility to help solve it."

—ROBERT TRESTMAN, M.D., PH.D., CHAIR OF PSYCHIATRY AND BEHAVIORAL MEDICINE AT CARILION CLINIC AND CO-CHAIR OF ITS OPIOID TASK FORCE

"The really lovely thing about Roanoke is that the population is so diverse—we look like America—and Carilion can leverage many different resources that allow us all to work together for innovative change."

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—SHIRLEY HOLLAND, VICE PRESIDENT OF PLANNING AND COMMUNITY DEVELOPMENT AT CARILION CLINIC

PHOTOS: JARED LADIA (DRS. TRESTMAN AND DUNSMORE) AND DARRYLE ARNOLD (HOLLAND)

EXTENDING THE TEAM: Physician assistant Joel Bashore oversees the development of advanced clinical practitioners in Carilion Clinic's emergency department.

Adjusting

AS THE DEMAND FOR CARE GROWS, CARILION IS EXPANDING THE ROLE OF ADVANCED CLINICAL

WITH BABY BOOMERS AGING AND THE Affordable Care Act extending health care coverage to many of the previously uninsured, demand for clinical care in the United States is at an all-time high. More patients mean more office visits—and physicians alone cannot meet the increasing need. It's a problem that taxes our health care system—and could overwhelm it were it not for an important group of players on the clinical care team: advanced clinical practitioners, or ACPs.

ACPs are licensed medical professionals—primarily physician assistants and nurse practitioners—who hold advanced degrees and typically practice medicine in collaboration with physicians. Under the Affordable Care Act, ACPs have been recognized as primary care providers, and they're becoming increasingly responsible for routine office visits and frontline care. In some states, including Virginia, they even maintain their own, separate panel of patients.

for growth

PRACTITIONERS TO IMPROVE PATIENT ACCESS TO QUALITY CARE. // BY VERONICA MEADE-KELLY

At Carilion Clinic, the number of ACPs has grown roughly 40 percent over the past five years to roughly 350. Collectively, ACPs handled greater than 20 percent of the nearly 400,000 patient encounters at Carilion last year alone.

"We have ACPs in pretty much all medical and surgical areas of Carilion," says Patrice M. Weiss, M.D., Carilion's chief medical officer and executive vice president. "They are vital members of the health care team, and they've heightened our ability to provide our patients access to care."

Once viewed more as support staff, ACPs have taken on added responsibilities in recent years and now enjoy what could be described as collaborative autonomy, shouldering more of the day-to-day decision-making in the clinic as they work alongside physicians and other health care providers.

"At Carilion, physicians view ACPs as partners," Dr. Weiss says. "It's very much a team concept for health care delivery."

That model, argues J. Randy Howell, D.H.Sc., P.A.-C., an emergency medicine physician assistant at Carilion, epitomizes the oft-cited ideal of patient-centered care.

"Gone are the days of the solo physician practicing out on their own," Howell says. "To fill the unmet health care needs in this country, what you're seeing at Carilion and other hospital systems is this team approach, with patients at the center of a large group of health care professionals—physicians, nurses, physician assistants, nurse practitioners, nurse midwives, certified registered nurse anesthetists, and many others—all working together to optimize quality and access to care. Patients really benefit from this collaborative, interprofessional approach."

"We aren't just ancillary staff anymore. ACPs are dedicated, hard-working professionals who truly care about our patients, our community, and the success of our organization."

—JOEL BASHORE, P.A.-C., ACP MANAGER, DEPARTMENT OF EMERGENCY MEDICINE, CARILION CLINIC

Building the Talent Pool

In giving this once-ancillary group of caregivers a more central role in patient care, this new model also tacitly calls for more and more specially trained medical professionals.

Traditionally, ACPs have learned on the job after leaving graduate school. For any given specialty, that could mean an ACP might work two to four years, depending on assignments and job responsibilities, before feeling comfortable enough to work autonomously. At Carilion, a series of fellowship programs is changing that.

In 2012, Howell and Joel Bashore, P.A.-C., ACP manager of Carilion's Department of Emergency Medicine, proposed a novel program that would offer ACP trainees a year of intensive, specialized training—in their case, in emergency medicine—to more efficiently and effectively prepare them to be autonomous health care providers in their medical area of interest.

The department welcomed its first three fellows in 2013, and soon the model caught on. In just five years, Carilion has expanded the program to include ACP fellowships in orthopaedic surgery, urgent care and rural health, acute care surgery, and wilderness medicine.

While the fellowships coordinate some basic training and share start and end dates, each fellow is immersed in his or her specialty and completes rotations in various subspecialties throughout the year. The orthopaedic surgery fellow, for instance, might rotate between hand surgery, sports medicine, and joint replacement at various points in the fellowship.

What is common to all the programs is the general structure: The programs are run by indi-

Assistance, please

THE ROLE OF ADVANCED CLINICAL PRACTITIONERS IN THE UNITED STATES HAS GROWN ALONGSIDE THE

The story of advanced clinical practitioners in the United States is rooted in need: Whether on the frontier, in the wilderness, on the battlefield, or in remote, rural regions, these medical care providers have, throughout history, stepped in to help wherever and whenever there were not enough doctors to go around.

Antecedents to modern advanced clinical practitioners, such as physician assistants and nurse practitioners, are many and varied. In the military, there were Navy hospital mates modeled after the 19th-century "loblolly boys" who assisted physicians in the British Royal Navy, as well as field medics, the real-life equivalent of such cinematic characters as Corporal Irvin Wade in *Saving Private Ryan*.

On the home front, there were groups such as the Frontier Nursing Service, which nurse-midwife Mary Breckinridge founded in 1925 to provide expectant women in the hills and hollows of Kentucky with midwives. There were also hospital aides, such as Vivien Thomas, a surgical technician renowned for his pioneering techniques in cardiac surgery.

Advanced clinical practitioners weren't formally recognized professionally in the United States until the latter half of the twentieth century, though, when demand for health care rapidly outstripped the supply of trained medical doctors following the institution of Medicaid and Medicare.

PHOTOS: JARED LADIA, PREVIOUS SPREAD; MARK LAMBERT, ABOVE

vidual departments, and fellows work clinical shifts under the close supervision and tutelage of senior, experienced clinicians in that specialty. Like a physician's clinical rotations or postgraduate fellowship, the ACP fellowships are compressed training experiences that provide a more intense, structured, and focused learning opportunity than a new ACP would ordinarily receive on the job over several years. And there's an opportunity for trainees to stay on at Carilion after completion of the program.

"It benefits both the system and the candidate: If the trainee is contemplating staying, the fellowship serves essentially as a one-year job interview," Bashore says. "Trainees are a known quantity to the staff and, if the fellows are a good fit and choose to stay, they are in position to make the transition seamlessly."

Perhaps the most novel facet of the fellowships is that they are open to both physician assistants and nurse practitioners—groups whose training has traditionally remained separate. The decision recognizes the reality that, in the clinical setting, physician assistant and nurse practitioner responsibilities are similar.

"Clinically speaking, in our emergency department, because of the identical roles they fill, the only way you can really tell the difference between physician assistants and nurse practitioners is to get close enough to read their badges," says Howell, who, in addition to co-founding the ACP fellowship program, is director of Carilion's emergency medicine fellowship for ACPs. "Physician assistants and nurse practitioners do essentially the same work—and they do many of the things that physicians do."

Recognizing that overlap, Howell argues, reflects Carilion's dedication to interprofessional practice and the "team" view of health care delivery.

"Our goal is to provide excellent care for patients, so anything we can do to get rid of barriers between our respective professions is incredibly important," he says. "We want our team to work collaboratively to enhance patient care."

Trusted Partners

The elevation of ACPs has also led to their inclusion in decision-making bodies across the Carilion system.

In 2014, Howell, Bashore, and others helped form Carilion's first ACP Council, made up of ACPs across specialties and institutions. As a body, the council provides a forum for discussion and development of policy initiatives important to ACP scopes of practice. The council also offers an advisory channel to executive administration about ACP practice and role development systemwide.

ACPs have been added to committees and advisory boards such as the Medical Education Committee and the Carilion Centralized Credentialing Committee. At Carilion New River Valley Medical Center, ACPs are now voting members of the medical staff and, throughout Carilion, ACPs are finding themselves in more leadership and management positions than they did in the past.

"It's a recognition that ACPs bring a great deal to the table as health care professionals," Bashore says. "We aren't just ancillary staff anymore. ACPs are dedicated, hard-working professionals who truly care about our patients, our community, and the success of our organization. Our inclusion in institutional decision-making says that we deserve as much of a voice as anyone on the team."

For their part, Dr. Weiss and other Carilion leaders believe that the success of the organization and the success of ACPs are very much interdependent.

"As the population ages and as it continues to grow, health needs are increasing throughout the country," Dr. Weiss says. "As we expand the number and roles of ACPs at Carilion, we're going to remove some of the barriers that would otherwise limit patients' access to care. Our care providers will take care of more patients, and the quality of care will continue to improve as we work together to treat patients as a team." CM

HEALTH NEEDS OF AMERICANS THROUGHOUT THE COUNTRY'S HISTORY.

Many credit that formalization to Eugene Stead, Jr., M.D., who, after using medical students and residents to staff Atlanta's Grady Hospital during World War II, became convinced that trained support staff could fill gaps in health care delivery.

In 1957, Dr. Stead partnered with Thelma Ingles, R.N., to develop the first master's degree program for nurse clinicians. Although the program was denied accreditation, he remained undeterred. Less than a decade later, he created a "physician's assistant" program at Duke University to employ medically trained military corpsmen. The first nurse practitioner training program was recognized two years later, when a public health nurse, Loretta Ford, and a pediatrician, Henry Silver, M.D., founded a program at the University of Colorado.

The role and recognition of advanced clinical practitioners has continued to expand ever since.

MISSION CRITICAL: The Second World War helped demonstrate the wisdom of using medics with different backgrounds.

PHOTO: COURTESY OF THE NATIONAL ARCHIVES

Virginia Tech Carilion Research Institute scientists record the first clear evidence of the interplay between serotonin and dopamine in humans. BY ASHLEY WENNERSHERRON

SCIENTISTS AT THE VIRGINIA Tech Carilion Research Institute have begun to unravel how serotonin acts, based on data collected in a first-of-its-kind experiment that used electrochemical probes implanted into the brains of awake human beings.

The neurotransmitter serotonin is associated with mood and helps shape the decisions we make.

The readings were collected during brain surgery as patients played an investment game before receiving deep brain stimulation as a treatment to try to alleviate symptoms of Parkinson's disease.

The study, conducted in collaboration with Wake Forest School of Medicine, appears in the May 2018 issue of *Neuropsychopharmacology*, a publication in the *Nature* family of journals.

The research provides the first-ever recordings of simultaneous sub-second fluctuations in serotonin and dopamine during active decision-making in a conscious human subject. The analysis provides new understanding of serotonin's role in regulating human choice and how it operates alongside dopamine, a neurotransmitter long associated with reward and its reinforcement.

"This is the first clear evidence, in any species, that the serotonergic system acts as an opponent to dopamine signaling," says Read Montague, Ph.D., senior author on the paper and director of the Human Neuroimaging Laboratory and the Computational Psychiatry Unit, both at the Virginia Tech Carilion Research Institute. "If a person didn't expect a positive outcome in the game but they received one, dopamine goes up while serotonin goes down."

Kenneth Kishida, Ph.D., co-first author on the paper and a research scientist at the institute at the time of data collection, worked directly with neurosurgeons at Wake Forest School of Medicine to take measurements of patients undergoing deep brain stimulation who volunteered to take part in the study.

Dr. Kishida, now an assistant professor in the departments of Physiology and Pharmacology, as well as Neurosurgery, at Wake Forest School of Medicine, is developing this work with larger patient cohorts and increasingly realistic environments.

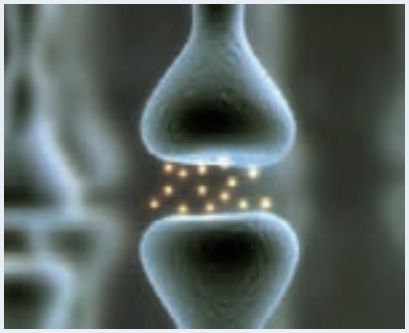
As the research subjects played the investment game, serotonin appeared to act as a caution signal to prevent them from overreacting to an outcome. As the neurotransmitter is implicated in prevalent neuropsychiatric disorders, including depression, the researchers aim to uncover how the chemical aids humans in developing adaptive actions.

"We found that serotonin is highly active in the part of the brain that helps us to navigate bad outcomes in a way that ensures we don't overreact to them," says Rosalyn Moran, Ph.D., now a reader at the Institute for Psychiatry, Psychology, and Neuroscience in King's College London. At the time of the data collection, Dr. Moran was an assistant professor at the Virginia Tech Carilion Research Institute.

Measure for Measure

To record dopamine and, more recently, serotonin signals in sub-second fluctuations for the first time took decades of preparation—and ingenuity. The research team that achieved those landmark readings had to develop extremely sensitive methods.

Led by Read Montague, Ph.D., director of the Human Neuroimaging Laboratory and the Computational Psychiatry Unit, both at the Virginia Tech Carilion Research Institute, the team modified a carbon fiber electrode previously used to measure dopamine fluctuations in rodents. They adapted the electrode to interface with surgical needs during a clinical procedure of patients with Parkinson's disease, to reduce surgical time and risks. Surgeons then placed the electrode in each patient's striatum, near the center of the brain.



The researchers took readings of ultra-quick dopamine pulses as conscious patients played an investment game. The scientists expected to see dopamine responses in direct relation to expected rewards and actual outcomes. They didn't.

"We analyzed the dataset of about a thousand pulses of dopamine, and it was flat," says Dr. Montague. "The signals did not distinguish between a positive reaction and a negative one."

The scientists used fast-scan cyclic voltammetry to measure the pulses of dopamine in the patients' brains. This electrochemical technique allows for near-continuous measurements of chemical activity in the brain. In this case, it was used to measure the dopamine signaling 10 times each second, for several minutes, while patients made financially risky decisions.

Once the researchers had the measurements, they started to analyze what the dopamine was actually signaling. They used new machine-learning methods, which employ several computational tools that help scientists dive deeper into data and emerge with more nuanced information.

"We found that dopamine tracks two factors—what happened and what could have happened," Dr. Montague says. "Our dopamine

"Serotonin acts in a way that reminds us to pay attention and learn from bad things, and to promote behaviors that are less risk seeking but also less risk averse," Dr. Moran says. "When there's an imbalance of serotonin, you might hide in a corner or run toward the fire, when you should really be doing something in between."

The researchers refer to this middle-of-the-road behavior promotion as a "keep calm and carry on" motif. Here, serotonin appears to temper excitement over positive outcomes while softening the potential disappointment of negative outcomes. This process can go awry when the neurotransmitter levels aren't in balance.

The research team will soon begin data collection at Carilion Clinic, through collaboration with Mark Witcher, M.D., a functional neurosurgeon. Dr. Witcher, who is also an author on the paper, became a collaborator on the project when he was the chief surgery resident at Wake Forest School of Medicine. He is now an attending physician at Carilion and an assistant professor of surgery at the Virginia Tech Carilion School of Medicine.

ON THE BRAIN: Dr. Read Montague focuses his work principally in the field of computational psychiatry, which offers a new, mathematically based lexicon for understanding mental disorders.

The work is critical. According to the National Institute of Mental Health, more than 10 million adults in the United States have suffered at least one major depressive episode. About half of those people take antidepressants, which primarily consist of selective serotonin reuptake inhibitors. The drugs are designed to keep serotonin at elevated levels in the brain by limiting the neurotransmitter's reabsorption.

"People take drugs to manipulate their serotonin when they have such low levels they can't work or they may even be a suicide threat," Dr. Montague says, noting that prior to his team's work, the best measurement tool for serotonin was positron emission tomography, or PET, scanning, which measures one point every two minutes. "Now, we can measure a point every 100 milliseconds. It's a completely different ballgame in terms of the time regime that we're in and the implications for understanding human behavior." CM

neurons appear to track whether something could have been better or worse, and this information is encoded by the rapid changes in dopamine release. These findings may start to reveal, in computational terms, what's missing in the dopamine system of Parkinson's patients."

The findings have been more than 20 years in the making, since Dr. Montague's first computational studies examining the mechanisms of dopamine signaling.

"Dopamine encodes what are called reward-prediction errors—the ongoing difference between reward expectations and the actual rewards experienced," Dr. Montague says. "From just dopamine signals, we can see when a person expects a reward and whether the person receives the reward. But we found this earlier model of reward-prediction error to be incomplete. Rather, dopamine pulses appear to combine information about what might have happened with information about what actually happened. This is an entirely new way of viewing the role of dopamine signaling in the human brain."

The idea that "what could have been" is part of how people evaluate actual outcomes is not new. Yet no one expected that dopamine would be doing the job of combining this information in the human brain.

"We married two known computational models into something new," Dr. Montague says. "In doing so, we found dopamine tracking and combining two streams of information into one chemical pulse."

Now that researchers have measured multiple contributions to the individual dopamine signals, they have even more pathways to explore the human brain's learning systems in health and disease.

Since their initial sub-second recordings of dopamine in 2015, Dr. Montague and his colleagues have worked to understand whether their discovery applies to people who don't have Parkinson's. The scientists' prior research, using functional magnetic resonance imaging, suggested that the new model should hold true in healthy individuals as well. Yet the previous work lacked the precision of the team's new measurements.

"Dr. Montague's innovations in recording dopamine and serotonin signals offer a breakthrough, and I don't use that word lightly," says Michael Friedlander, Ph.D., executive director of the Virginia Tech Carilion Research Institute. "Being able to take precise, real-time measurements in the living human brain will help us understand the mechanisms of decision-making in health and disease."

IMAGES: ISTOCK (LEFT); DAVID HUNGATE (ABOVE)

A CONTAGION IN LAUGHTER

The medical school's most recent art show honors a beloved Roanoke physician. **BY CATHERINE DOSS**

THE SPRING ART SHOW AT THE Virginia Tech Carilion School of Medicine pays tribute to Julien H. Meyer Jr., M.D., a Roanoke physician who passed away last year. The show, "Laughter Is the Best Medicine," which will run through mid-July, features works by nearly 60 local artists and is inspired by two of Dr. Meyer's passions: art and humor.

A Roanoke native, Dr. Meyer was an obstetrician and gynecologist for 43 years at Physicians to Women, Inc. Throughout his career, he was renowned for his skill in incorporating humor into his work.

"There is a contagion in laughter," Dr. Meyer said in 2016, while accepting the Robert L.A. Keeley Healing Arts Award for his service to the medical community of the Roanoke Valley. "It is a social glue, and it helps patients feel more at ease. Humor and a sunny presence make for good bedside manner."

Dr. Meyer went on to note that patients had told him they never thought a gynecologic visit could be such fun.

"Joking was only a small part of Julien's upbeat and humorous personality," said Lynn Meyer, his wife of 28 years. "He truly loved being a physician and looked forward to going to work each day. He often said he had a captive audience akin to show business."

Dr. Meyer took special interest in mentoring Virginia Tech Carilion School of Medicine students. He also embodied many of the school's core values, especially patient-centered care and community involvement.

"My father was always joking with his patients," said Jeff Vespa, Dr. Meyer's youngest son, who contributed to the art show some of his humorous portraits of Hollywood actors. "He would wear a red foam clown nose or put a large plastic cockroach on the exam table to make people laugh. I miss him every day and know the community does too." CM

PHOTOS: ALEJANDRA MORAL

A MESSAGE OF MIRTH

The "Laughter Is the Best Medicine" art show included selections from photographer Alejandra Moral's "We the Women," a series of images of women expressing joy. Through these portraits, Moral seeks to empower future generations of women, to inspire them to chase their dreams and to remind them that together they can shape a new society free of gender norms and stereotypes. "I create photographs that speak beyond the image," she writes, "beyond the standardized beauty of women, and tell stories of growth, embrace, and celebration."

cheers for peers

Emergency Medicine

MATTHEW BORLOZ, M.D., medical director for Emergency Medicine at Carilion New River Valley Medical Center, was named by *Annals of Emergency Medicine* as a Top 50 Reviewer and a Distinguished Senior Reviewer.

Family Medicine

MARK GREENAWALD, M.D., vice chair of academic affairs for Family and Community Medicine, was the plenary speaker at the American Academy of Family Physicians' 2018 Residency Education Symposium in late March. His presentation was titled "Calibrating the Leader: Being Well While Leading Well."

Internal Medicine

STEVEN KATOR, M.D., a hospitalist with Carilion Stonewall Jackson Hospital, was named a diplomate in clinical informatics by the American Board of Preventive Medicine.

The Teaching Excellence Academy for Collaborative Healthcare (TEACH)—a collaboration between Carilion, the Virginia Tech Carilion School of Medicine, and Jefferson College of Health Sciences—recently announced the first annual TEACH Awards. Recipients included **CLAUDIA KROKER-BODE, M.D., PH.D.,** who received the Innovative Teaching Award, and **P.J. WHALEN, M.D.,** a pediatric hospitalist who received the Faculty Feedback Award.

LUKAS LOSCHNER, M.D., a physician with Pulmonary Medicine, and **BRADLEY ICARD, D.O.,** a fellow in Pulmonary/Critical Care, were members of a team that was awarded a Research Eureka Accelerator Program (REAP) grant from the Edward Via College of Osteopathic Medicine. The collaborators will use the grant to work on a proposal to develop a point-of-care diagnostic kit for bacterial and viral pneumonia.

PAUL YEATON, M.D., section chief of Gastroenterology, was named a GI Leader to Know by *Becker's GI and Endoscopy*.

Obstetrics and Gynecology

EDUARDO LARA-TORRE, M.D., vice chair of academics and section chief of General Obstetrics and Gynecology, was named president-elect of the North American Society for Pediatric and Adolescent Gynecology, which is dedicated to providing multidisciplinary leadership in education, research, and gynecologic care to improve the reproductive health of youth. Dr. Lara-Torre's term began in April 2018.

FIDEL VALEA, M.D., chair of Obstetrics and Gynecology, has been named to the board of directors of the American Board of Obstetrics and Gynecology. His three-year term as director of gynecologic oncology will begin this year.

KIMBERLY SIMCOX, D.O., was named a diplomate in addiction medicine by the American Board of Preventive Medicine.

PATRICE M. WEISS, M.D., chief medical officer and executive vice president, was named to the "100 Hospital and Health System CMOs to Know 2018" list of *Becker's Hospital Review*. The list features national physician leaders dedicated to strengthening their organizations through physician leadership development, patient safety initiatives, and quality improvement.

Orthopaedics

JONATHAN CARMOUCHE, M.D., section chief of Orthopaedic Spine, was named a Spine Surgeon Leader to Know by *Becker's Spine Review*. Dr. Carmouche was also chosen to receive one of the first Research Domain Mentors Award given by the Virginia Tech Carilion School of Medicine, along with **ZHI SHENG, PH.D.,** an assistant professor at the Virginia Tech Carilion Research Institute. Recipients were nominated by the school's current students and alumni.

T.K. MILLER, M.D., section chief of Sports Medicine, was named a principal reviewer for the *American Journal of Sports Medicine*. The peer-reviewed scientific journal is the official publication of the American Orthopaedic Society for Sports Medicine.

JOSEPH MOSKAL, M.D., chair of Orthopaedics, was named an Orthopaedic Surgeon to Know by *Becker's Orthopedic Review*.

PHOTO, TOP LEFT: JARED LADIA

Psychiatry

TRACEY CRISS, M.D., a psychiatrist and vice president of medical staff and credentialing, was awarded the Nancy C.A. Roeske, M.D., Certificate of Recognition for Excellence in Medical Student Education by the American Psychiatric Association. The annual award is given to association members who have made outstanding and sustaining contributions to medical student education.

Radiology

DANIEL KAROLYI, M.D., PH.D., vice chair of Imaging, taught a three-day body MRI course in Sydney as a joint venture between the Royal Australian and New Zealand College of Radiologists and the American College of Radiology.

Surgery

CHARLES HARRIS, M.D., was recently elected president of the Virginia Chapter of the American College of Surgeons.

MARIA HIRSCH, C.R.N.A., director of certified registered nurse anesthetists for Carilion Roanoke Memorial Hospital, is a member of a national research team that was recognized by the American Association of Nurse Anesthetists with the John F. Garde Researcher of the Year Award. She also was elected treasurer for the Council on Accreditation of Nurse Anesthesia Programs, and she served as an editor for the sixth edition of *Nurse Anesthesia*, published by Elsevier-Saunders.

Residency and Fellowship Programs

ALEXANDRA NASSIF, P.A.-C., advanced clinical practitioner fellow with Urgent Care Medicine, coauthored a case report, "Medication-Induced Pruritius from Direct Oral Anticoagulants," published in the December issue of *Federal Practitioner*.

Two fourth-year Surgery residents presented at the Virginia Chapter of the American College of Surgeons' Committee on Trauma Resident Paper Competition in Richmond. **HANNAH WORIAX, M.D.,** presented "Is the Face an Airbag for the Brain and Torso? The Potential Protective Effects of Severe Midface Fractures." **ASHLEY GERRISH, M.D.,** presented "Post Discharge Mortality after Geriatric Low Level Falls: A Five Year Analysis."

Affiliated Institutions

The Virginia Hospital and Healthcare Association has recognized **NATHANIEL L. BISHOP, D.MIN.,** president of Jefferson College of Health Sciences, with its Meritorious Service Award for significant contributions to the health care field through commitment to service and leadership.

The Roanoke-Blacksburg Technology Council honored **DEBORAH KELLY, PH.D.,** with its Innovator of the Year Award. Dr. Kelly, an associate professor at the Virginia Tech Carilion Research Institute, focuses on developing new methodologies to study complex biological machinery, including the formation of breast cancer.

This spring, **READ MONTAGUE, PH.D.,** director of the Human Neuroimaging Laboratory at the Virginia Tech Carilion Research Institute, became the 41st person to present the annual Dorcas Cummings Memorial Lecture at the Cold Spring Harbor Laboratory Symposium on Quantitative Biology, Brains and Behavior: Order and Disorder in the Nervous System. Six Nobel Prize laureates have previously given the lecture, including Francis Crick, Ph.D., one of three winners of the prize in physiology or medicine for the discovery of the structure of DNA.

RICHARD VARI, PH.D., senior dean for academic affairs at the Virginia Tech Carilion School of Medicine, has been appointed president of the International Association of Medical Science Educators (IAMSE). His two-year term began in January. IAMSE is an international nonprofit professional development society focused on promoting excellence in health professions education.

Provider Excellence

The Carilion Clinic Provider Excellence Awards recognize providers who demonstrate dedication and exceptional care to patients, families, staff, and fellow providers. This year's awardees are:

KIMBERLY SIMCOX, D.O., a physician with Obstetrics and Gynecology, received the Provider Excellence Award for Physicians.

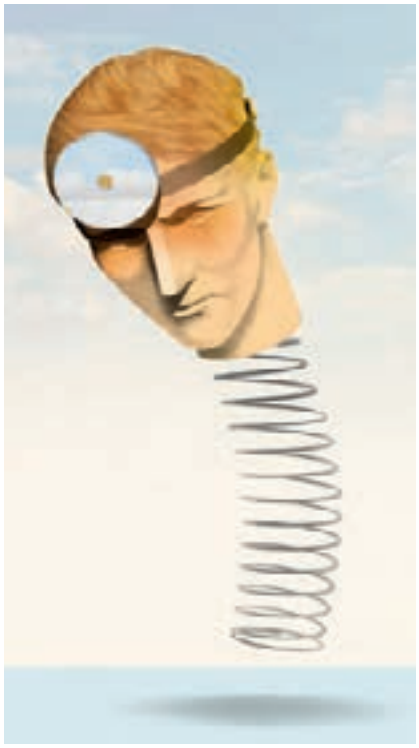
CALEB PAGLIASOTTI, M.D., a resident with Psychiatry and Behavioral Medicine, received the Provider Excellence Award for Residents and Fellows.

LAURA JONES, N.P., a hospitalist at Carilion Roanoke Memorial Hospital, received the Provider Excellence Award for Advanced Clinical Practitioners.

THE RESILIENCY CODE

To do their jobs well, physicians must be able to open themselves up to pain—and then figure out how to bounce back. **BY GARY R. SIMONDS, M.D.**

IT'S EARLY EVENING WHEN MY CALL PAGER sounds. It's a 15-year-old with a gunshot wound to the head; he's already beyond saving. As I console a room packed with loved ones, a half dozen other calls stack up. Some are simple: a blood pressure medicine here, a new CT scan there. Others, though, are complex and emotionally wrought: a 38-year-old mother of three in a coma, a postop aneurysm patient who's looking fragile.



Within two hours, another teenager comes in with a traumatic brain injury; he'll probably survive. An elderly woman with a hemorrhagic stroke has a good prognosis as well. Yet a 43-year-old with a broken back and paralysis in the legs needs to go to surgery, stat. I speak with several families and tackle four more emergency room consults and nine more floor calls.

It's nearly midnight, and now it's a 48-year-old with what is a likely a malignant brain tumor; it doesn't look good. A few more patients with spine fractures that should heal in braces. More families. Then a 32-year-old with a massive subdural hematoma sends me back to surgery. When I emerge, the waiting room is filled with people.

And so it goes. It's a bad night, though not atypical: many desperately ill people, many grieving and anxious families, a great deal of tragedy. No promise of sleep—or even rest—until tomorrow evening.

It isn't the tragedies themselves. It's not the horrible injuries, the deaths, or the sometimes sickening ironies. It's neither the volume nor the ferocity of it all that gets in. I trained for a long, long time to be as impenetrable as possible, to not feel, to be able to focus on the problem at hand. I have to: I'm a brain surgeon, for goodness sake.

For me, it's speaking with the families in the very worst of scenarios. I'm good at it, and it oddly brings me fulfillment—I sometimes cannot help the patient, yet I can help his or her loved ones. To do it well, to do it *really* well, I think we have to open ourselves up to feeling. We must feel and process their pain and anxiety. We must walk for a short time in their shoes, to help them along the path. And once the shields go down, "it" gets in, it *all* gets in. Stack up several in short order, and our shields are in disarray.

Different stressors affect different providers in different ways. None of us is truly impervious, however.

My colleagues and I, along with renowned physician resilience expert Wayne Sotile, Ph.D., have spent the past five years exploring how and why "it" gets in, the damage "it" can do, and how we can build resilience against "its" effects. Many talks, a podcast, and two books—*Building Resilience in Neurosurgical Residents* and *The Thriving Physician*—have followed.

Care providers, take the time to reflect and care for yourself. Because "it" always gets in. CM

Gary R. Simonds, M.D., is chief of neurosurgery at Carilion Clinic.

ILLUSTRATION: BRETT RYDER

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We congratulate and thank the physicians and clinical staff whose teamwork and dedication made this milestone in surgical heart valve replacement possible, and who continue to position Carilion as the region's leader in heart care. Most importantly, we thank our patients for entrusting us with their care.

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LEADERSHIP IN ACTION

The investiture of Nancy Howell Agee as chair of the American Hospital Association's board of trustees inspired reflection on the national state of health care.

online exclusives

Practice With Purpose

Carilion Clinic's new simulation center places a focus on enhancing patient safety, medical education, and innovation.

Removing a Stigma

A Carilion Clinic team is collaborating with colleagues in Nigeria to teach clinical techniques and raise awareness of epilepsy.

In Good Company

Jefferson College of Health Sciences explores what it would mean to merge with Radford University.

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