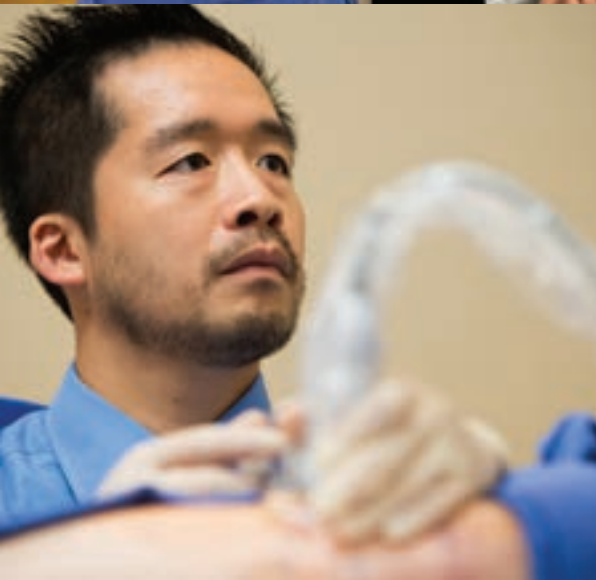


# Advancing the Frontiers of Rehabilitation Medicine and Research

2015 Year In Review

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In 2015, the UPMC Rehabilitation Institute celebrated its 15th anniversary. I'm very proud of how far we've come in such a relatively short period of time. We've seen our annual grant funding leap from \$200,000 a year to well over \$6 million. Inpatient beds now number over 200. We've been able to

significantly grow our faculty positions from eight to more than 60, and we now offer four fellowship programs every year. How much we've changed.

Change is a driving aspect of our department, of our work, and of our people. In this our inaugural highlights report, you'll read about some of these changes: in our pediatric rehabilitation programs, traumatic brain injury, stroke, outpatient care, and neural prosthetics research among others. This report is a small sample of the work that makes up our Institute and Department. I am pleased and honored to share it with you. You'll see the faces of our staff and patients, and you'll learn how we are working across disciplines to conceptualize and affect change.



Speaking of change, many of you already know that the next time you see a message from the Director of the UPMC Rehabilitation Institute and Chair of the Department the message won't be from me. Instead it will be from the department's new leader, Gwen Sowa MD, PhD. I'm completely thrilled that the search for my replacement ended with Gwen. She is the complete package in terms of research, education, and administrative skills. The Department and Institute could not be in better hands.

Why the change? There are several reasons. For one, I was offered a great, new position providing medical leadership to UPMC's entire post-acute care enterprise. This new job will enable me to help shape a future for our organization that not only deals with but embraces the changes brought about by bundling, ACOs, and value-based care. While this is a big job, it actually will give me more time for what has always been my passion - research and mentorship. Gwen has asked me to be her Vice Chair for Research, and I have accepted. Lastly, I thought UPMC would invest in a new chair and that the department would benefit, not only from this reinvestment, but also from new energy and ideas. As far as the investment part goes, I was right. Gwen will have all the resources to realize her lofty goals for the department.

I can't wait to see where we are 15 years from now.

**Michael L. Boninger, MD**

A handwritten signature in black ink, appearing to read "Michael L. Boninger" with a stylized "MD" at the end.

*Director, UPMC Rehabilitation Institute  
Professor and UPMC Endowed Chair,  
Department of Physical Medicine and Rehabilitation,  
University of Pittsburgh School of Medicine*

# Pediatric Rehabilitation:

## A Big Program for Small Children

For children who experienced a traumatic brain injury, spinal cord injury, chronic conditions such as spina bifida, cerebral palsy, Down syndrome, or even those in need of a transplant, the pediatric rehabilitation medicine programs at Children's Hospital of Pittsburgh of UPMC are providing comprehensive care for a growing number of patients. With a dedicated inpatient unit and a number of multidisciplinary outpatient clinics throughout western Pennsylvania, children and their families are able to receive highly-coordinated, expert care for challenging conditions that can affect every aspect of their lives, in and out of the hospital. The goals of the myriad programs are to maximize function, train families about their child's new or changing functional status, provide for community reintegration — including school reintegration — and develop accommodations that will help children be more successful in their daily activities.

### Starting from Scratch

Since 2012, the programs have experienced tremendous growth and expansion in the specialized services they provide, the types of patients they can assist, and the overall volume of patients. Amy J. Houtrow, MD, PhD, MPH, associate professor and vice chair of pediatric rehabilitation, joined the organization in 2012 and assumed responsibilities for creating a multidimensional, multidisciplinary rehabilitation program that could tend to the specialized needs of a pediatric population in both inpatient and outpatient settings. "The vision of our program is to integrate functioning as part of health throughout the continuum

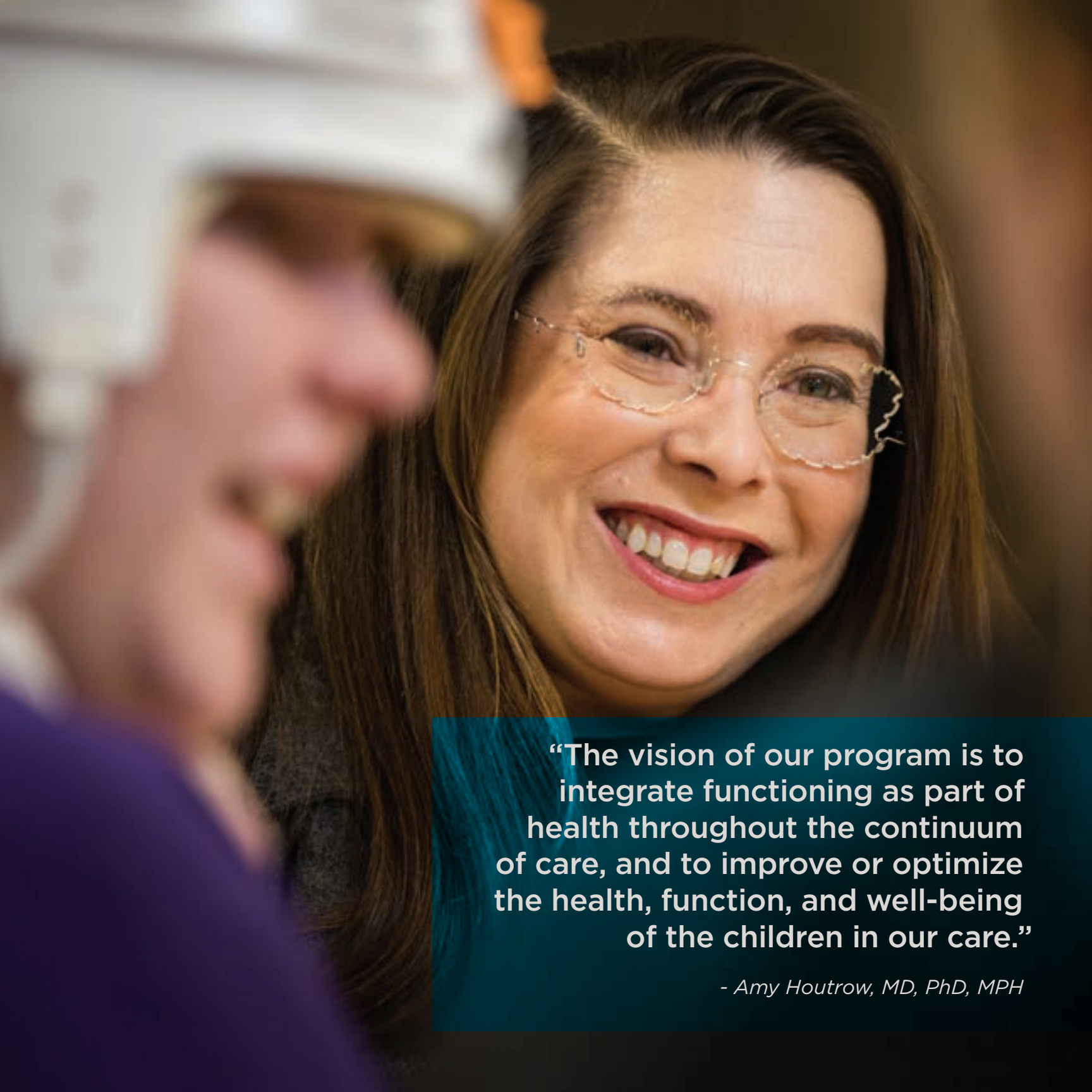
of care, and to improve or optimize the health, function, and well-being of the children in our care," says Dr. Houtrow.

In rapid succession, Dr. Houtrow brought several clinicians to expand the scope and reach of the programs. "Along with Jason Edinger, DO, (who arrived in 2011) I was able to hire Angela Garcia, MD, our graduating fellow, and then Dina Patterson, MD," says Dr. Houtrow. And from that point the building began in earnest. "Initially, we established a procedure clinic for spasticity management, and then added EMG testing," says Dr. Houtrow.

But that was only the beginning. More clinics would follow, and Dr. Houtrow

continued to add faculty and staff to grow the department. At present, the division of pediatric rehabilitation has six physicians, as well as a host of additional support staff covering a range of disciplines.

To advance the overall mission and vision of the program, Dr. Houtrow and her colleagues worked to develop additional clinics in the outpatient sector, as well as to establish a dedicated, eight-bed inpatient unit, the Children's Hospital Rehabilitation Unit (CHRU) in conjunction with a structured consultation service. "We needed to add an additional faculty member in the fall of 2013 because we were expanding our consultation service and opening the CHRU. That's when



**“The vision of our program is to integrate functioning as part of health throughout the continuum of care, and to improve or optimize the health, function, and well-being of the children in our care.”**

*- Amy Houtrow, MD, PhD, MPH*



Amit Sinha, MD, joined our team as the associate inpatient medical director," says Dr. Houtrow.

### Big Progress in Short Order

In a little over three years, "We've been able to grow our program to include a large group of providers and a comprehensive set of services," says Dr. Houtrow. That sentiment is borne out by the number of staff and the number of clinics, but also by the volume and diversity of patients the collective programs are able to care for, and the change in the underlying approach to how pediatric rehabilitation medicine is delivered.

important for me when I came here was the opportunity to help move the field forward, away from pediatric rehabilitation services as something that happened only after a major illness, injury, or surgery, to a model in which functioning is considered an integral part of health at every stage of a patient's condition."

Additionally, Dr. Houtrow's division recently assumed responsibility for overseeing pediatric neuropsychology at Children's Hospital. "This is an exciting recent development because pediatric neuropsychology is well aligned with pediatric rehabilitation since it involves

contribute to a greater understanding of the discipline. "There are few places that are well-resourced in terms of pediatric rehabilitation medicine. I have six pediatric rehab physicians in my group, and we are one of the biggest in the country now," says Dr. Houtrow. As a leading program in the country it is important for Dr. Houtrow and her team to be present on the national stage, contributing in terms of service to organizations, helping to bolster an understanding of what pediatric rehabilitation is and the conceptual framework grounded in improving function, and thinking about it in terms of every stage of a child's life, and throughout the health care continuum.

**"Our goal is to optimize the medical, emotional, and functional health of the child."**

*- Amit Sinha, MD*

Historically the core of pediatric rehabilitation focused on brain and spinal cord injuries. What Dr. Houtrow's programs have sought to accomplish is to make sure that there is a home for children who are medically complicated so they can receive the type of rehabilitative care that helps them become as functional as possible for their overall health and recovery. "One of the things that was

cognitive function and dysfunction, and adaptations to help children be as successful as possible in their learning and thinking," she says.

Beyond her own programs in Pittsburgh and throughout western Pennsylvania, Dr. Houtrow and the division are heavily involved with pediatric rehabilitation medicine at the national level, working to

### Inpatient Care for the Most Challenging Cases

Since the inpatient and consultation programs launched in 2013, they have experienced significant growth and expansion. "Any time you are trying to establish a level of trust with other providers, whether general pediatric service, cardiology, transplant, neurology, neurosurgery, and so forth, it takes time. They are entrusting us with their patients, who they may have referred elsewhere in the past, and they want to have the highest level of confidence in the care they will receive. In the last few years, we have been able to make those connections and build those relationships," says Dr. Sinha.

# Community Outreach and Volunteer Work

Volunteer work and community outreach programs provide valuable services and support to those most in need. Many of the clinicians in the division of pediatric rehabilitation devote their time and energy to programs in local communities, across the country, and around the world.

## **U.S. Paralympics Track and Field**

Since 2013 Amit Sinha, MD has volunteered his time to help classify athletes for U.S. Paralympics Track and Field events – to make sure individuals are competing against those with similar functional abilities. Dr. Sinha's work entails functional examinations before classifications are made, observing athletes during warm-ups and competition to ensure individuals have been properly classified. Dr. Sinha will continue his efforts and attend the U.S. Paralympic National Classification Summit in October.

## **Medical Outreach Around the Globe**

Angela Garcia, MD and Jason Edinger, DO have both devoted time in the past to providing medical outreach and care in different parts of the world, using their skills and expertise to make a positive impact. Dr. Garcia recently completed a medical mission trip to Haiti with the Wheeling Jesuit Physical Therapy Program. Dr. Garcia and colleagues tend to children at an orphanage in the town of Petionville. Dr. Garcia performs medical and developmental assessments as well as creating programs and educational materials for volunteers and staff at the orphanage. "The children we see at the orphanage may have cerebral palsy, spina bifida, arthrogyrposis, hydrocephalus, malnutrition, and other concerns. The experience is life changing," says Dr. Garcia. Most recently Dr. Edinger has volunteered his time with the Wheeling Jesuit University School of Physical Therapy to



provide medical assistance and outreach at the Maternidad de Maria maternal hospital in Chimbote, Peru. Dr. Edinger sees children in a clinic at the hospital, visits schools, and advises therapists and providers on the ground with recommendations on the care of children with special needs.

#### **Making Summer Camp a Reality: Camp INSPIRE**

Developed by Jason Edinger, DO in a collaboration between Children's Hospital and The Woodlands Foundation where he serves as medical director, Camp INSPIRE is a summer camp for children and adolescents up to 21 years of age that have tracheostomies or need ventilators to help them breathe. The camp and support staff allow these children to enjoy a typical camp environment and activities in a medically-supervised environment. Camp activities such as archery, and campfire sessions, a dance, talent shows, craft

projects are all adapted so that campers can have many of the typical summer camp experiences that most people are familiar with.

Started in 2013, the camp has been able to offer a rich experience each year for a growing number of children and young adults with medically complex issues. There are no costs to children or their families for the program. Many volunteers from Children's Hospital including NICU staff, medical students, residents, and others devote their time to creating a memorable, safe, and rewarding experience for campers. "I really see camp as the ultimate extension of pediatric rehabilitation medicine. What we're trying to do is allow kids to be more ingrained in the community, doing and enjoying things outside of school and the home, and summer camp is a great way to do that," says Dr. Edinger.

### **Acute Care Consultations**

The consultation service sees close to 500 patients a year, with a wide range of conditions. Approximately half of the cases end up being appropriate for comprehensive, inpatient rehabilitation services, while the rest may be addressed in other ways. Dr. Sinha explains, "The most frequent reason we are consulted is to evaluate whether or not a child or young adult needs inpatient rehabilitation, or what their level of function is after an injury or illness. We see patients who have spinal cord injuries, traumatic brain injuries, orthopaedic injuries, or a combination of traumatic injuries. The consultation service seeks to identify the best way to meet their rehabilitation needs. Sometimes that means we are recommending inpatient services, and sometimes that means recommending medication or outpatient follow-up in one of our clinics. Any child who has any significant functional deficit due to injury, illness, or surgery is an appropriate child for us to see and help care for in the hospital."

Depending on the patient, the consult service is able to help guide when a patient is stable, but also work closely with the therapists to understand how much assistance a child or young adult will need to accomplish critical functions, such as getting out of bed and walking

to the bathroom, or going up and down stairs. The clinicians take a thorough history of what the home environment looks like, assessing how easy or difficult it will be to move around given the patient's condition and needs. "A lot of what we do is work closely with the family, seeing where the child is both functionally and medically, how much help they need, and how the home environment affects the situation. We combine all of these factors to develop the best plan for each patient," says Dr. Sinha.

### **Comprehensive Inpatient Services**

To be truly successful in caring for pediatric patients, a rehabilitation program must be comprehensive and multidisciplinary, addressing not only direct patient needs, but family needs, psycho-social support, and community and school reintegration complexities. Approximately 100 children a year come through the CHRU, and those children are cared for by a devoted, comprehensive team, providing an array of services for both the patient and family. "Our goal is to optimize the medical, emotional, and functional health of the child, and also to a certain extent the family. In many cases you have a child who goes from functioning age appropriately to potentially needing significant amounts of help to get out of bed or do any of their activities of daily living. This obviously not only affects the child, but it affects the

parents and entire family unit, and we have to address that," says Dr. Sinha.

The team on the CHRU consists of rehabilitation physicians and nurses, as well as physical, occupational and speech therapists, psychologists, and social workers. To this, the program adds a behavioral psychologist and a neuropsychologist. The CHRU also employs some less well known, but equally important disciplines that extend the range of care available for both patients and their families. "Our team includes a recreational therapist, school teacher, and care coordinator, and their services add an extra dimension to our care, allowing us to take some of the burdens off of the family while they are here, but most importantly, when they are about to leave inpatient care," says Dr. Sinha.

The recreational therapist helps families and children realize what they can do for fun. Prior to injury or illness, the child may have played football, but after an injury that may no longer be possible. The recreational therapist works with both the patient and family to devise activities or modifications to activities that would be beneficial from a leisure standpoint. "As human beings there has to be some leisure component to our lives. We need that for emotional wellbeing. This is particularly the case with children. Play



is what they do, it's how they learn, so we work to preserve that aspect of their lives as best we can," says Dr. Sinha.

Transition back to school after an injury or illness is often challenging. Modifications at school may be in order, especially from a cognitive standpoint. And for those with mobility issues, or who are in need of specialized equipment, how transportation to and from school occurs is important. In

some form or another, for most children, school will probably look different than it did before their injury or illness. "Our school teacher plays a huge role in communicating between the parents, the school district, and our team to discuss what our recommendations are. Should this child go to school full time right away? Are they going to go back half-days, a few days a week? Do

they need an individualized education plan? Our teacher plays a huge role in implementing this plan, again, to lessen the burden on the family," says Dr. Sinha.

For children who need inpatient rehabilitation, their care can be lengthy and complicated. Part of the therapy process is to tend to their emotional well being. The department actively coordinates special trips outside the

hospital for community reintegration, to understand how children interact with their environment. Sometimes this entails taking in a baseball game, or they may simply visit a store so therapists can see how they react in real-world environments.

### **Simplifying the Discharge Process**

The CHRU team has gone to great lengths to simplify the discharge process for patients and families, examining it from every angle. Family education is addressed in regard to the individual patient's care needs before they leave the unit. Follow-up appointments are scheduled and coordinated with the necessary outpatient clinics, or other care providers specific to a patient's condition. Much of this is handled by the care coordinator who works to ensure that every family has all of the logistical challenges mapped out before they ever leave the hospital. "We've created a separate document that we hand families with their outpatient medical appointments, outpatient therapies, all their medications, medication schedules, the education plan, any special equipment or braces that we ordered, and a list of who to call if they have questions. It's all about making it as clear as possible and reducing stress," says Dr. Sinha.

The CHRU team also facilitates the transmission of discharge papers to any of the outpatient clinics a patient may

visit after going home. "We built a process in the electronic medical record where the comprehensive discharge document can be sent to our outpatient nurses so they have something to refer to when the patient or the family calls because they may not have had any direct contact with the outpatient group up to that point," says Dr. Sinha.

For medications the patient needs, the care coordinator ensures that any prescriptions are filled by the in-house pharmacy and given to the family along with all the other discharge information. "Our goal is to have all medications in the parent's hands when they leave so they are not taking a bunch of prescriptions to the pharmacy the day of discharge only to realize the pharmacy doesn't carry a particular medication. Our nurses review the medication list to ensure none have been missed, and they also review them with the parents," says Dr. Sinha.

### **Tending to Medically Complex Cases**

Children's Hospital of Pittsburgh of UPMC has an internationally renowned transplant program. These children require complicated, ongoing medical management for their posttransplant care, and the CHRU team collaborates closely with the transplant nurse practitioner for patients who find their way to the rehabilitation unit for care. "Our transplant patients are quite

medically complex and the transplant team works with us to optimize a number of medical issues that can be ongoing at any given point in time. We don't see every transplant patient. Some are simply too medically fragile for our rehabilitation services, but for those who can benefit, we collaborate extensively with their transplant team," says Dr. Sinha.

"We know that the longer it takes to become mobilized, the more difficult it will be to regain function. We don't want to lose the time while the child is still making medical recovery and needs to be in a hospital setting. We gain a lot of value by bringing them to rehabilitation where they can still have all the medical management that they need with their transplant team. It's a really good use of the patient's time especially in terms of getting ready to go home. We also have the advantage of having time for training with families," says Dr. Houtrow.

A process that the CHRU team enacted through the rehabilitation coordinator was to begin a dialogue with the transplant coordinator several weeks in advance of the patient arriving on the unit. "We enacted this process to ensure a seamless transition," says Dr. Sinha. "These children are pretty complex in terms of the number of medications they are on, managing their immunosuppressants, or when to

adjust their immunosuppressants. For a lot of the small and large bowel replacements, their immunosuppressants depend on what their most recent biopsy results are so oftentimes they have biopsies every one to two weeks and we are working with the transplant team to understand what the biopsy looks like. Can we adjust the steroids? Can we adjust immunosuppressants? And that's where we are relying on their expertise to guide us."

### Extending Our Reach Into the Communities We Serve

The same type of multidisciplinary, comprehensive care that the pediatric rehabilitation team at the CHRU provides to inpatients is extended to outpatients through a number of clinics that address the ongoing needs of patients with long recovery trajectories, or those with chronic, life-long conditions. Seeing several thousand patients each year, there is a large population of children that the program cares for and follows in the outpatient setting.

### Spina Bifida Clinic

The Spina Bifida Clinic cares for close to 700 children every year, with comprehensive care for patients up to 22 years of age. The program addresses all aspects of care for both the patient and family, as well as referrals to additional

community support services. An important aspect of the program is its collaboration with the UPMC Adult Spina Bifida Clinic, as team members are able to seamlessly transition patients over to the program when appropriate. This level of continuity of care with the only adult clinic in western Pennsylvania is a hallmark of the program and a great service to patients and families.

### Community Outreach Clinics

In four outlying communities across western Pennsylvania, the pediatric rehabilitation teams see patients with any number of conditions associated with disability. These clinics are positioned to allow for closer-to-home care for patients and their families. The clinics see patients with any type of condition that's associated with disability. This includes things such as cerebral palsy, autism spectrum disorder, Down syndrome, to less complex issues like having trouble toe-walking or not being able to walk well. "These clinics, along with our CP and Spina Bifida clinics are all funded in part by the state and they all include involvement from multiple disciplines, not just our physical medicine and rehabilitation specialists," says Dr. Houtrow.

Dr. Houtrow also notes that the outreach clinics have recently expanded to serve patients in West Virginia through clinics with Easter Seals.

### Other Specialized Services for Outpatients

The division also runs a number of other outpatient clinics and is engaged in collaborative efforts with other departments at Children's Hospital to extend their ability to assist greater numbers of patients. "We run a multidisciplinary Brain Injury Follow-up Clinic for children who have either acquired brain injury from a traumatic cause or other condition such as encephalitis or stroke. We also partner with our neurosurgery colleagues for spasticity management, and with our neurology colleagues for neuromuscular disease, which is partially funded by the Muscular Dystrophy Association," says Dr. Houtrow.

"We've expanded services in a lot of different areas over the last several years," indicates Dr. Houtrow. This includes expanded services in a multidisciplinary chronic pain program that Drs. Sinha and Garcia attend along with a pain anesthesiologist, a physical therapist, and a psychologist.

"Another success for us has been in collaboration with the UPMC Sports Medicine Concussion Program," says Dr. Houtrow. "Alongside the neuropsychology management the program provides, we see the subset of kids who have prolonged symptoms and may need medication management or additional therapy, or adaptations to help them go back to school."

## Research, Training, and Beyond

Dr. Houtrow is engaged in numerous research and training projects, not only to advance the programs at Children's Hospital, but also to expand the knowledge base of the entire discipline. As a researcher, her primary areas of focus include examining the trends in childhood disability, how disability affects the entire family unit, and how they interact with the broader health care system, including access to care for children with disabilities. Dr. Houtrow also is involved, along with Brad Dicianno, MD, medical director of the human engineering research laboratories, and medical director of the of the Adult Spina Bifida Clinic, in a Spina Bifida Registry Project funded by the Centers for Disease Control and Prevention (CDC). "This project is aimed at determining standards of care for children and adults with spina bifida and has been ongoing for several years," says Dr. Houtrow.

Dr. Houtrow's other research projects include investigating outcomes of in utero surgical intervention for myelomeningocele;

studying the management of deep venous thrombosis in children; evaluating trends in pediatric rehabilitation care; and analyzing neurostimulant use in pediatric brain injury. Her health services research investigates disadvantages associated with living in poverty, and the social determinants of health and health inequities experienced by children with disabilities.

Beyond her clinical, administrative, and research duties, Dr. Houtrow participates on standing committees for the Medicine, and is part of the leadership for the American Academy of Physical Medicine and Rehabilitation, the American Academy of Pediatrics, and the Association of Academic Physiatrists. "For me, being active in these groups and serving on committees is an important way that I, and our department, can help advance our field. When we do this work we are advancing the objectives that we have for children so that they can be as happy, healthy, and capable as possible," she says. ■

# Transitional Rehabilitation Units:

## Expanding Options for Patient Care

In 2015, the UPMC Rehabilitation Institute opened new Transitional Rehabilitation Units (TRUs) in four skilled nursing and rehabilitation facilities that are part of UPMC Senior Communities.

The TRUs are designed for relatively short stays for patients recovering from surgery, illness, or accidents, and who are not yet ready to go home but no longer need the care of an acute facility. Patients admitted to the TRUs typically need additional care, resources, and intensive therapy, and the goal is to help patients return to their previous level of activity or better, and return them home as soon as possible.

“It’s very important for patients to get the most appropriate level of care after they are discharged from the hospital,” says Gwendolyn Sowa, MD, PhD, associate professor and incoming chair, Department of Physical Medicine and Rehabilitation. “Through the TRUs, we’re helping to expand and elevate the already excellent care provided at the skilled nursing facilities by creating new partnerships with all health care professionals involved in a patients’ care — from the point of admission to their return home. This collaboration ensures that patients have continuity of excellent care at every stage of their rehabilitation.”

### TRUs by the Numbers

The four TRUs have greatly extended the reach of the UPMC Rehabilitation Institute and contain a combined 134 beds in recently remodeled wings of the skilled nursing facilities. Additionally, a medical director and certified nurse practitioner lead the clinical team at each TRU, and the unit staff has been trained on all aspects of rehabilitation patient care and management.

The average length of stay for most patients on the TRUs is one to two weeks. “Where we used to be at a 28 to 30 day length of stay (LOS), we’ve been able to work our average LOS down to 10 to 14 days across the network,” says Shelly Ciaramella, RN, clinical nurse liaison and senior manager of business development of post-acute services for both UPMC Senior Communities and the UPMC Rehabilitation Institute.

Discharging patients to their homes is one of the primary goals of the TRUs. Across the four facilities, 82.5 percent of patients are discharged to home. “We’ve developed collaborative processes to not only identify patients who can benefit from TRU care, but to smooth the referral and transition process to our post-acute environment,” says Ms. Ciaramella.

“Our goal is to get the patient to the most appropriate level of care for their needs, and to work with them in a very intensive way to get them back home again as soon as possible. When we do that, it’s a win for everyone,” says Ms. Ciaramella.

# Stroke Rehabilitation and Research

## An Integrated Approach

Stroke is the leading cause of disability in the United States and fifth ranked cause of mortality. While the risk factors are well known, it is still an injury that can strike without warning and lead to debilitating deficits. The Stroke Rehabilitation Program at the UPMC Rehabilitation Institute encompasses dedicated units within eight UPMC acute care hospitals throughout western Pennsylvania. The strength of the program lies in the collaborative work between the clinical care providers tending to patients in the inpatient units and outpatient facilities, and the research teams investigating the causes, personal biological factors, new and novel technologies, and therapeutic techniques that can translate to improved patient care.

The Department of Physical Medicine and Rehabilitation is one of the top five funding recipients for rehabilitation research from the National Institutes of Health (NIH). The department's research program is engaged in trying to solve some of the most complex and challenging questions related to stroke, as well as evaluating the use of technology to evolve the basic science and translational knowledge base that informs and drives best practices in patient care.

### Collaborative and Comprehensive Care

For Jennifer Shen, MD, assistant professor, and medical director of the inpatient stroke rehabilitation unit at UPMC Mercy, optimal patient care for complex stroke patients requires a team. "Because stroke can cause multiple impairments, in areas such as speech, swallowing, motor skills, and cognition, we have to address each person on an individual level, using a multidisciplinary, team-based approach to help that person's overall function," says Dr. Shen.

In addition to physicians, the inpatient team includes physical therapy, occupational therapy, speech therapy, and neuropsychology, as well as specially trained rehabilitation nurses. Dr. Shen says, "The idea is to address every one of the patient's needs as a team. It's more than just medications; it's more than just walking. We have to remember that adjusting to this sudden, new diagnosis is extremely difficult for both the individual and their family. We take into account the family dynamic, social integration needs, and the community reintegration

component that comes after they leave our unit."

How the inpatient rehabilitation team functions at UPMC is explained by Dr. Shen with an example. "If the speech therapist advises us that the best way for a particular person to communicate is with a written yes/no response, we carry that technique through for all the team members. It becomes something that is reinforced not just when they are in a speech therapy session but also when they're working with physical therapy, or the nurse is talking to them about their



pain. Similarly, if an occupational therapist finds that somebody who needs a lot of assistance with transfers does best with a certain technique, that's something that gets communicated to the rest of the team. This way, when the nurses are promoting patient's bladder continence outside of therapy times, they know the transfer technique that's worked well for the patient and therapist. It's all about continual communication, individualized for each patient."

For consistency and collaboration, there is a committee that assesses each of the eight inpatient units. "If one unit is doing a technique really well, instead of the other units having to reinvent the wheel, we bring that technique over. If it needs to be modified or customized to take into account the specifics of an individual unit, then we do so. These are ways that we

can learn from each other and that's something that we're constantly doing, whether it's stroke specific, or rehabilitation in general," says Dr. Shen. Collaborative efforts extend outside the rehab unit as well. "We are inherently collaborative with other subspecialties, neurology, neurosurgery, trauma, and our research partners. The collaboration has to be strong to ensure we are carrying forward the good work that they did," says Dr. Shen.

### **Patient and Family-Centered - Always**

For stroke survivors and their families, it's extremely overwhelming to have a stroke and to begin the recovery process. The individual's specific stroke, the mechanism for why the stroke occurred, and the risk factors that need to be managed to decrease future risk are complex. "What we often find is that people may only be in acute care for just a few days. When they come to rehab and they have the ability to





spend a couple of weeks with us, the reality sets in and gives us an opportunity to work on education," indicates Dr. Shen.

As is the case with so many conditions, everyone is different when it comes to their stroke. For every individual with stroke that Dr. Shen and her colleagues see, they attempt to understand in detail what the patient was like before they had the stroke. "We want to know about their personality and how they were functioning — were they at a very high level? Were they active and engaged, or were they perhaps struggling with depression or anxiety?"



These are issues that can be critical factors in how to approach treatment, and how the person might respond to the condition. Unfortunately, post-stroke depression is very common. We're vigilant about monitoring for it, because of the risks."

Determining the best course of treatment for any patient begins with an understanding of their recovery goals — in the long term, as well as more immediately. The desires of the patient and family cannot be

overlooked. Dr. Shen explains, "One of the first questions we ask is, 'What's your long term goal?' Every rehab facility in the U.S. meets once a week for a sit down, in depth discussion of every patient that is on the unit, as a standard of care. However, at UPMC, we meet almost every day to ensure we're tracking in the right direction."

In addition to the long-term vision of recovery, the therapy teams work with each patient on short-term goals for the week. Dr. Shen comments, "For example, this week our goals might be to get consistent yes and no responses, so the person can express basic wants and needs, and to work on bladder continence. Beyond this we layer an interdisciplinary staffing discussion, meeting on a daily basis to review changes. A medical change can affect how therapy progresses, or vice versa, and so the entire team needs to be in constant communication. It's incredibly important when you have so many specialists working together for common goals."

Developing an individualized plan of care for each survivor and their family, while on the unit and when they return home, is the heart of the matter. This takes as many shapes as there are individuals. "It makes sense that how we treat each patient is different. If somebody is neglecting one side of their body, then all the therapists and nurses focus on bringing attention towards that side. Families can be a key

part of this process. We may ask them to sit on the neglected side to draw attention toward that side and give them that continuous feedback. That's just one example; we take that team approach for many aspects depending upon their needs," says Dr. Shen.

### **Education for All Is Key**

For Dr. Shen and her colleagues, the other part of rehabilitation is education. "I teach residents that when patients come to us, a large part of our job is education. It's a priority for the entire care team to educate the family and the patient. What to expect long term is hugely important because the brain recovers over not just days or weeks but months and years. We conduct a weekly education session for any of the individuals who are able to participate, as well as their families." Dr. Shen points out that many times these sessions provide a platform for a support group. It makes a difference to patients to hear not just the experts talking but also the person next to them who is going through a similar experience. "At our UPMC Mercy location there's a stroke support group each month designed to provide education as well as socialization. The community aspect is a huge part of it. A lot of individuals, and even the family members are dealing with significant isolation, especially if there's a high burden of care. These groups can be beneficial for everyone," says Dr. Shen.

## Clinical Innovations in Patient Care

The inpatient stroke units within the UPMC Rehabilitation Institute deliver exceptional care on a daily basis, but they also work to develop and implement new strategies and techniques and deploy new technologies to support, nurture, and set patients up to achieve their long-term recovery goals. "It's an interesting time to be doing rehabilitation," says Dr. Shen, "when technology is becoming so easily accessible and advancing so quickly. If we use it to our advantage, it makes the therapy sessions more efficacious; it can help with an individual's participation and even their buy-in or enjoyment." What we know about brain recovery is that the

more an activity can be enjoyable, it engages the reward centers of the brain. This kind of activity increases participation and engagement and overall improvement and function.


### Helping Patients with Upper Extremity Weakness

Across the UPMC Rehabilitation Institute, a number of technologies are employed to engage and assist with patient recovery. Nintendo Wii® devices are used because of their ability to engage multiple systems and add an element of fun and competition to the recovery process.

The Armeo® upper extremity training device is used by therapists to assist

patients experiencing various upper arm motion deficits. "The person's arm is supported in a boom-type apparatus. In front of them they have a computer and video game system. So in the beginning let's say all you have is a little bit of movement at the shoulder. The device will support the entire arm and the game might be something as simple as catching raindrops in a cup as they fall on the screen, moving the cup left and right."

"The beauty of this is that the weak arm is supported; this allows the therapist to direct and coach the patient. We can increase the intensity over time to continually challenge the patient. At the same time, it also helps those who are



**"Cognitive and mood changes tend to influence outcomes just as much as motor impairment."**

*- Elizabeth Skidmore, PhD, OTR/L*

dealing with neglect or visual field deficits,” says Dr. Shen.

### **Visualizing a Patient’s Gait**

A pilot quality improvement study, championed by then PM&R resident Prakash Jayabalan, MD, PhD, Recording the Gait of Stroke Patients During Rehabilitation to Improve Motivation, Satisfaction, and Outcome, conducted by a team of clinicians from the Department of Physical Medicine and Rehabilitation devised a study using a tablet computer to video record a stroke patient’s gait over time, as a way of providing visual evidence of their progress with the goals of determining whether or not this type of feedback would lead to increased motivation, participation, and an improved functional outcome.

By recording gait at intervals, and presenting the videos along with graphs illustrating changes in their walking ability over time, the study pointed to increases in participation levels, as well as the desire to continue with therapy from a motivational perspective. Assessing individuals through a number of devices including the Pittsburgh Rehabilitation Participation Scale, a structured satisfaction questionnaire, and timed-up-and-go and 10 meter walk tests, 80% of people found the videos and graphs equally useful. 100% of the test group indicated that the intervention improved their satisfaction of their rehabilitation stay.

Dr. Shen was a member of the pilot study team and indicates that after the results



were analyzed and presented, it became clear that, “this intervention was very patient-focused and patient-centered. The pilot study also led to additional funding from the Beckwith Institute for Innovation in Patient Care to formalize the program. The team now has a mobile platform that includes a video capture system and software that can record pertinent videos, allowing therapists to use the device for any of their sessions.”

### **Supporting Patients with Non-Supported Training**

For a subset of stroke patients with balance issues, taking a hands-off approach can often prove very beneficial. “Non-supported gait training is a technique

that our physical therapists may use with stroke patients. Usually these are patients who don’t necessarily need a lot of assistance but are still working on balance or coordination issues. The therapist has the person ambulate and instead of continuously keeping contact, they position themselves to intervene only if necessary,” says Dr. Shen.

The non-supported training keeps the patient safe the entire time, but they are also allowed to lose their balance and attempt to self-correct. Dr. Shen says, “The idea is to learn how to self-correct rather than depend on someone else to correct for you.”

## Research to Inform Better Patient Care

Elizabeth Skidmore, PhD, OTR/L, chair of the Department of Occupational Therapy has a joint appointment in the Department of Physical Medicine and Rehabilitation. As a clinician, Dr. Skidmore has over two decades of direct patient care experience as an occupational therapist. Her primary investigative interests in stroke rehabilitation relates to studies of cognitive and mood impairments. Recently, she has been studying the use of meta-cognitive strategy training in acute stroke rehabilitation to improve patient outcomes. “We have invested a fair amount of time in studying how to best treat motor problems, but I think we have a poor understanding of how we can address cognitive and mood changes, and yet cognitive and mood changes tend to influence outcomes just as much as motor impairment,” says Dr. Skidmore.

### Meta-Cognitive Strategy Training to Improve Stroke Recovery Outcomes

Cognitive impairments routinely affect a large number of stroke patients and have lasting effects on overall health and quality of life. Cognitive deficits also can have an impact on the patient’s rehabilitation process during and after the acute phase. As is the case with most therapeutic interventions, there are numerous paths that can be chosen for patient care to optimize outcomes. The same is true for stroke patients.

Therapists and physicians have at their disposal many techniques and interventions to use with patients who need to relearn skills after a stroke. Meta-cognitive strategy training (MCST), the focus of Dr. Skidmore’s research, is showing promising results on a number of fronts for patients in acute rehabilitation.

Dr. Skidmore and her research colleagues first began investigating the use of MCST in 2009 in individuals with cognitive impairment after stroke. Since then they have published a host of research on its role and effectiveness during the acute rehabilitation phase to help stroke patients overcome deficits, relearn skills, and mitigate the development of behavioral or mood issues detrimental to the rehabilitation process, such as apathy. “Strategy training is an intervention that really teaches an individual how to guide their own learning. The underlying philosophy is that patients are only in acute rehabilitation for a short period of time, but will, we hope, have a long life after rehab. The role of strategy training is to teach patients how to address problems that they encounter, and to address any number of difficulties they may face long after they leave rehab,” says Dr. Skidmore.

Strategy training is in contrast with direct skill teaching, another approach widely used by rehabilitation programs where there is a very specific skill that the patient needs to learn and the therapist

tells them exactly how to do it. Both are valuable approaches, but they might be used at different times for different purposes. “Our data would suggest that by far most rehabilitation being delivered uses direct skill teaching. I started studying strategy training as an alternative. It’s not new, it’s been around since the 1950s. You’ll find it prominently in education research, in psychology research, and in business and quality improvement research,” says Dr. Skidmore. “There have even been some studies in individuals with chronic cognitive deficits or chronic behavioral problems. However, until we started this work we hadn’t examined whether strategy training could be used in inpatient rehabilitation among individuals with acute cognitive impairments.” One of the main reasons why people with cognitive impairments have poor outcomes is that they have a hard time learning new skills. “If we use direct skill teaching, patients will execute the task as you instruct them but they may not remember how to do so the next time without help, and this problem may continue over time. This is one of the reasons why we started studying strategy training as an alternative,” says Dr. Skidmore.

### Engaging Patients in the Early Phases of Rehab

In stroke rehabilitation, there is substantial evidence suggesting that the acute post-stroke period – the first six months – is a critical period for a patient’s recovery

## Noninvasive Brain Stimulation

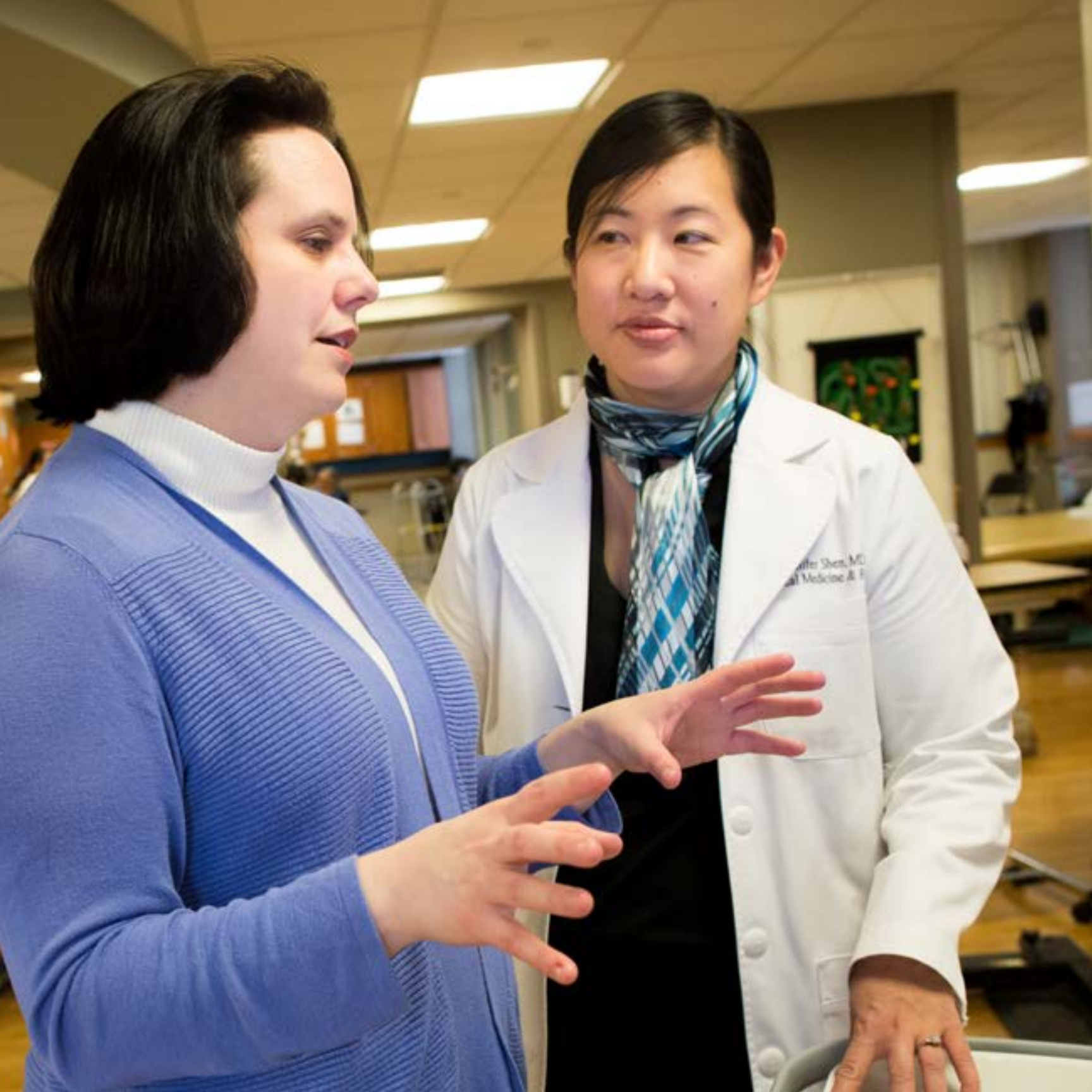
Approximately 85% of patients have weakness in one hand after a stroke. This hand weakness may or may not improve, even six months after the injury, leading to long-term impairments in activities of everyday living. In May 2015, Amit Sethi, PhD, OTR/L began a two-year pilot study looking at the use of noninvasive brain stimulation for stroke patients to augment and improve motor control and weakness in the hands.

The study involves a six-week treatment program with three non-invasive brain stimulation treatments a week. Individuals receive weak electrical currents (less than two milliamps) through a specially designed cap with electrodes placed around the affected area of the brain. "What we know about these types of electrical currents is that when applied to the area of the brain affected by the stroke, the surrounding area

has the potential to acquire the function of the damaged area," explains Dr. Sethi. Each treatment session lasts 30 minutes, and Dr. Sethi and his team perform testing of brain activity, muscle activity of the weakened hand, as well as clinical tests of day-to-day functioning to determine whether the effect is being carried over in everyday tasks. Dr. Sethi explains, "We bring patients back three months after their last treatment to see whether the gains they made in the lab persisted."

In addition to the electrical stimulation while performing tasks, patients are given a home exercise program. The research therapists follow up every two weeks with questionnaires about progress and function, and to determine if their therapy plans need to be modified. "Ultimately, we hope to allow patients to regain as much motion and motor control in the affected hand as possible," says Dr. Sethi.







as spontaneous changes occurring in the brain and body can be augmented with rehabilitation for potentially better outcomes. "Finding an intervention that we could deliver immediately after a stroke became really important. I began to wonder if we taught people how to identify and solve problems earlier, would they develop good habits that would in turn manifest in the long-term after they leave rehabilitation, promoting more independence," says Dr. Skidmore.

The brain can reorganize itself in order to support function. In the presence of a stroke, the brain does start to make better use of the neurons that were not damaged. "Evidence suggests that the sooner we engage people in the rehabilitation process the better chance we have to enhance the brain's ability to reorganize itself through neuroplasticity and help cognitively impaired patients relearn the skills and habits they need to function in their world," says Dr. Skidmore.

### Early Pilot Studies Show Significant Results

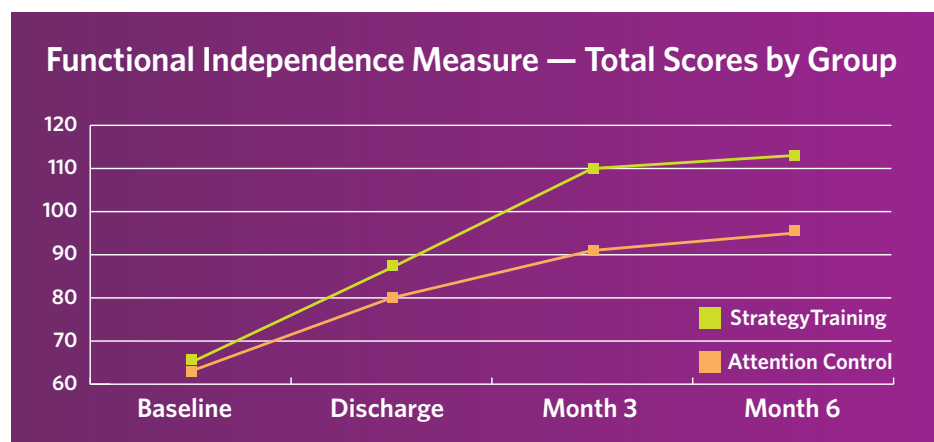
Before putting the intervention to work in a pilot study, Dr. Skidmore and her research colleagues needed to understand if the approach would have a negative effect on the rehabilitation process. Would it be too difficult on the patient, or take too much time, or expose them to unnecessary safety risks or disrupt the overall flow of care, forcing patients into a longer stay?

"Those were all important questions that we had to ask first, in addition to making sure that we could properly train the therapists and have them deliver the techniques reliably and consistently."

In clearing those preliminary hurdles, the stage was set to test the effectiveness of strategy training with a group of cognitively impaired stroke patients. Dr. Skidmore and her colleagues devised a pilot study to compare strategy training effects relative to a group of patients given an attention control condition. Thirty patients were randomized into two groups, and their regular therapy plans were augmented with 45 minute sessions, five days per week for their entire duration of acute rehabilitation on the unit, with either the strategy training interventions or the attention control condition. "We really wanted to know if they would become more independent over time." says Dr. Skidmore.

What the pilot study ultimately found was that both groups of patients got better, as measured by functional independence scales, at the same rate, but after they left rehab, the strategy training group continued to improve more than the attention control condition group.

"One thing that surprised me greatly, and surprised many people, is that we really thought this was an approach that would not necessarily help people with cognitive deficits improve their cognition, but rather it would help them be independent, work around their cognitive impairments, and create the necessary adaptations to manage their deficits. But when we ran that pilot study, the neuropsychologist that I work with suggested we measure cognition anyway. It is important to help these people reduce their disability, but if you could improve their cognition too, that would be fascinating," says Dr. Skidmore.



The pilot study measured cognition at three and six months, and what Dr. Skidmore found proved interesting. “We did not see differences between groups in some of the basic cognitive functions; people in both groups improved in memory, attention, language, and visual spatial function. But what did differ between groups is improvements in executive functions. Patients who received the strategy training showed dramatically improved executive functions comparatively, and this was unexpected. I don’t know that we can say convincingly that this will always be the case, but in the small sample we studied there was a large effect size of differences between groups. We are conducting another study to see if we can replicate this finding.”

Another finding of the pilot study points to differences in self-directed motivation between groups over the first six months after stroke. “We generally expect apathy symptoms to elevate around four to six months after a stroke, and it often comes along with depression. Participants who had strategy training maintained very low apathy symptoms; whereas people who did not receive strategy training showed increased levels of apathy symptoms over time, as is common after stroke. Strategy training participants were more goal

directed, they were able to initiate goal activities on their own, and they were more active over time,” says Dr. Skidmore.

### **Moving the Research Forward with a Multisite Clinical Trial**

With improved cognitive function in the pilot study, Dr. Skidmore and colleagues engaged in a multisite randomized controlled trial at six inpatient rehabilitation units within the UPMC Rehabilitation Institute. This study seeks to randomize 200 patients (to date 120 participants have been enrolled), and will run until 2018, at which time Dr. Skidmore and colleagues will publish the results. “In this study, we are looking not only at six-month outcomes as was done in the pilot, but 12-month outcomes too because we wish to understand whether participants who were able to complete a task during the first month after stroke are continuing to improve 12 months later. The long-term effects of strategy training, and whether or not they persist, is ultimately what we seek to understand,” says Dr. Skidmore.

### **Planning for Widespread Implementation**

With the research conducted so far pointing to benefits of strategy training for stroke patients with cognitive impairment, the team is developing an implementation study to understand the impact on care

when strategy training is applied to everyone who comes to rehab. “What we need to do is see what happens when strategy training is delivered throughout the health system. Do we get the same outcomes? Do we need to make adjustments?” says Dr. Skidmore.

The strategy training program that she and her colleagues have developed and put into practice in the pilot studies and current randomized trial has four components, and it takes approximately 10 hours to train a therapist to be reliable in delivering the intervention. “Before we can deliver strategy training in usual care, we need to optimize the intervention. We are currently planning an optimization study to see which of the components is most important in optimizing intervention outcomes. Do we need the whole package or can we streamline it? We have finished one study that answers part of that question, but we need to finish this research before the full picture becomes clear,” says Dr. Skidmore.

Dr. Skidmore and her colleagues also plan to gauge the impact of strategy training interventions on outcomes such as inpatient length of stay, rehospitalization prevention, and community placement after discharge.

## Clinical Care Collaborations

A hallmark of the rehabilitation research conducted at UPMC, echoed by both Dr. Skidmore and Dr. Shen, is the collaboration between researchers and clinical care providers to refine and improve patient care. "It's not really beneficial for us to conduct research about rehabilitation in isolation of clinical rehabilitation," says Dr. Skidmore.

From Dr. Skidmore's perspective there are many opportunities for therapists to work in research or quality improvement studies with the goal of changing the system of care. The UPMC Rehabilitation Institute's therapists and nurses are very active in research and often present their work at national and regional meetings. One recent example of the research and clinical collaboration to improve patient care was a study conducted to better assess the fall risk of stroke patients.

### A New Tool for the Assessment of Falls Risk in Stroke Patients

A study conducted by Terry Breisinger, MPT, PT; Grace Campbell, PhD, RN, MSW; Christian Niyonkuru, PhD; Lauren Terhorst, PhD; and Elizabeth Skidmore, PhD, OTR/L, sought to determine the accuracy of a new screening tool they developed to assess stroke patients for

fall risk. The Stroke Assessment of Fall Risk (SAFR) was a quality improvement project designed to better understand who is at the greatest risk for a fall while in inpatient rehabilitation.

The SAFR scale was compared against another UPMC screening tool, the Fall Harm Risk Screen, a standard tool used to predict fall risk for all hospitalized patients. "Most screening tools for fall risk are highly biased toward people with stroke, because people with stroke are by virtue of their stroke more at risk; the patients all look identical on these scales. The research team developed the SAFR tool to see if it could better predict specifically those stroke patients most at-risk for falls so we can more closely monitor them," says Dr. Skidmore.

The Fall Harm Risk Screen uses three criteria to assess patients: functional ability, falls history, and clinical judgment of fall risk. The SAFR scale, "is scored using clinical documentation from the first 72 hours of the inpatient rehabilitation admission. It assesses seven stroke-specific risk factors identified from the published literature and clinical audits. These comprise four impairments (impulsivity, hemi-neglect, and static and dynamic sitting balance) and three functional

limitations (lowest score on three Functional Independence Measure items: transfers, problem solving and memory)."

The study observed 419 patients who had suffered an ischemic or hemorrhagic stroke and were admitted for inpatient rehabilitation. In a direct comparison of the two tools, the sensitivity of the SAFR indicates that it will "accurately identify 78% of fallers," whereas the Fall Harm Risk Assessment "will correctly identify 57% of fallers." As the authors conclude in their paper, "Preliminary results suggest that in stroke inpatient rehabilitation, an evidence-derived, population-specific fall risk assessment may more accurately predict fallers than a general fall risk screen. The SAFR shows promise as such an assessment. Increasing fall prediction accuracy may help to decrease fall rates in inpatient stroke rehabilitation, thereby minimizing the harmful consequences of falls." ■

# Devastating Injuries:

## The Traumatic Brain Injury Program

Traumatic Brain Injuries (TBIs) are devastating, complex injuries, with often complicated, long-term rehabilitation and recovery processes – both physical and psychological.

The UPMC Rehabilitation Institute's dedicated, inpatient Traumatic Brain Injury program includes a full complement of rehabilitation services and technologies designed to address the specific needs of each individual patient. The program cares for approximately 300 patients each year who have suffered severe brain injuries as the result of any number of traumatic events – car and motorcycle accidents, falls, accidental drowning, and other anoxic events such as cardiac arrest or drug overdose. The TBI program ensures that there is a strong collaboration with acute care partners across UPMC. The TBI program has strong ties with neurosurgery partners, working closely with them to identify patients so they receive the right therapy at the right time, setting patients up for success before they reach the rehabilitation phase of their recovery.

Along with the comprehensive clinical care afforded to brain injury patients, the Department of Physical Medicine and Rehabilitation's TBI research program is one of the leading programs in the country. Amy K. Wagner, MD, associate professor and endowed research chair of physical medicine and rehabilitation, studies various aspects of TBI, the use of biomarkers, and the newly emerging field of Rehabilomics, in which she is a pioneering figure.

### A Model System

The UPMC Rehabilitation Institute's TBI program is one of a handful in the country to be designated as a Model Systems Center, receiving funding from the U.S. Department of Education's National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR). The 16 federally-funded TBI centers actively recruit patients with moderate to severe

TBI who need inpatient rehabilitation therapy. These patients are included in a national database that tracks and studies the individuals and their outcomes over their lifetime, or as long as they remain part of the national database project.

While there are a number of criteria that define what is, and who can be a Model System, a key aspect is affiliation with a level one or two trauma center. UPMC has

multiple level one and two trauma centers, and the trauma care provided affords the TBI researchers a wealth of information about patients that eventually end up participating in inpatient rehabilitation. For Dr. Wagner, the integrated and comprehensive nature of the UPMC system is a big advantage — for research and patient care — because most facilities just do not have the scale, depth of services,

and infrastructure to meet all the criteria of a Model System center. She says, "We've really been able to leverage the strengths of our trauma system in terms of establishing our impact on the larger model system network, emphasizing the integration of our trauma colleagues into our center."

Nationally, the TBI Model System Network has been in place for over 25 years. The UPMC program was most recently funded in 2012 and is up for renewal in 2017, but the program's history as a Model System dates back to 2003. Dr. Wagner explains, "The prospective data collection component to the national database project has our staff following patients over a lifetime after their enrollment. The national database is a tremendous resource intended to help us understand disability and function within this population over the lifespan. The longitudinal nature of the database is one of its greatest assets, along with the number of patients in the database, about 14,000 cases. There has, over time, been an evolution in the types of data collected and how it's collected, but from a capacity perspective, the Model System affords us the opportunity to study a large and heterogeneous population and characterize the issues that individuals with moderate to severe TBI have over their recovery course."

In terms of how its role as a Model System directly affects patient care, it opens up a





lot of possibility for collaboration. The ability to collaborate on a national level is where patients can benefit the most as no two brain injuries are exactly the same. In dealing with injuries which are multifaceted, being part of a collaborative network allows access to more powerful information, derived from the collective efforts of the other centers, that informs clinical practice to benefit patients.

### **Allowing for More Powerful Research**

For the researchers and clinicians studying TBI, the Model System affords opportunities to investigate and conduct research with increased rigor beyond what could be accomplished alone. Using the collective data captured from across the country allows for more powerful research with greater scale. Some of the early patients enrolled have been contributing data for 25 years. Understanding that TBI is often a life-long struggle for many patients, having access to early data about injuries, hospital care, and inpatient rehabilitation, and then how patients live and progress through the years, is a unique aspect of the program. Such information allows researchers to gauge patient outcomes long-term, and translate the findings to make continual improvement over all aspects of patient care — from immediately after the injury to many years later.

From an overall research perspective, Dr. Wagner notes, “The capacity for using

large datasets to really characterize a heterogeneous population drives a lot of what we can do. We’ve recently finished generating two large epidemiology studies evaluating posttraumatic epilepsy, and we are currently working on a third. The first study characterizes posttraumatic epilepsy within the TBI MS population nationally; the second study generates prognostic models to better understand risk factors for posttraumatic epilepsy. And now, our third study seeks to understand the toll of having a comorbid condition like epilepsy, in addition to a TBI, on mental health-related outcomes.”

### **Finding Deeper Associations in the Data**

While the Model System’s database contains an enormous amount of valuable information, it is not a perfect repository for researchers. A large gap in the information centers around the patient’s acute care or trauma history prior to rehabilitation. Dr. Wagner explains, “While we do collect some things about a patient’s acute care stay, it’s not comprehensive. We can access the National Trauma Databank, but there are no patient identifiers.”

Using a probabilistic approach to match data from both sets of records, Dr. Wagner and her trauma colleagues at UPMC, “Have used our local trauma center registry, along with our local Model Systems registry, to test an algorithm for probabilistic matching of anonymized

MS and trauma records. The results of the matching process algorithm were good enough to allow us to apply the algorithm to the Model Systems and the National Trauma Databank databases to produce a large database of patients with a full trauma and rehabilitation research record.”

Access to this full record has allowed Dr. Wagner and colleagues to generate interesting findings about contributors to suicidal behavior after TBI, using



trauma relevant data. In addition, she has worked with her trauma collaborators to investigate how early hospital-acquired pneumonia influences long-term outcomes over a five-year period. “These are questions that can’t be asked by any other investigators without this new matched database. Through this unique collaboration with the UPMC trauma team, we can begin to understand in depth how the trauma care received, and the details about the acute injury

and hospital care, play out in terms of long-term rehabilitation outcomes.”

From a health services perspective, Dr. Wagner and her colleagues are excited about the use of this data in relation to the types of research they can conduct, and its impact on the research that the broader Model System Network can conduct. “We are really excited that we can bring this matched database to the TBI Model System table. Being a part of an integrated health system such as UPMC allows us to do this kind of specialized research that other centers are not well positioned to do,” she says.

### **Excellence in Clinical Care for Traumatic Brain Injury**

Beyond its designation as a Model System research center, the TBI program provides comprehensive, evidence-based approaches to patient care and therapy. Patients are assessed, and individual plans of rehabilitation are developed that correlate to patient goals. The model of care is patient-centric, and a team approach engages the various disciplines at the right juncture for each patient.

The educational components of the program extend to both the patient and their family, and are critical elements to achieving an optimal outcome. The clinicians in the TBI program are often seen as primary care physicians, dealing

with a range of issues and the brain injury in its complexity with a comprehensive understanding of the brain injury itself and its associations to mental health, neurological complications, and

a specialized Disorders of Consciousness program. The goal of the program is to provide the early stages of rehabilitation for patients who cannot, or are only minimally able to, interact with their

**“Through our research programs, we’re well positioned to provide personalized solutions that are rehabilitation-specific, and unique tools and approaches that are increasingly recognized by the larger medical research establishment as valid and necessary for quality patient care.”**

*– Amy Wagner, MD*

psychosocial issues. Treating the whole individual in context of their larger social environment is paramount.

### **Disorders of Consciousness Program**

For brain injury patients in a coma, vegetative, or minimally conscious state, the UPMC Rehabilitation Institute offers

environment. The program has experienced growth and structural changes over the last year. The Disorders of Consciousness program looks different than other programs in the country. Most programs admit patients into long-term acute care facilities. The UPMC Rehabilitation Institute TBI program takes a different





approach by bringing patients into an acute rehabilitation setting. The program sets them up so that when they do potentially emerge from their state, they are positioned to continue with a normal course of therapy. The program's efforts revolve around preventing complications of immobility, which can be dramatic. Therapists and the nursing staff look at ways to prevent such things as skin complications or contractures of joints, or even treat the early stages of spasticity, and at the same time provide an environment that has an appropriate amount of sensory stimulation to engage patients.

The Disorders of Consciousness program is designed to support not just the patient but their entire family. It's a challenging time for family who are often grappling with a host of medical issues and concerns facing their family member. Once these immediate issues stabilize is when the rehabilitative process can begin. Providing the right amount of education to family so they know what to expect during every stage of recovery is necessary.

Given that all patients present in different ways, and families may or may not be able to digest information at certain points in the

process, there are several standardized approaches to family member education. Within the first week after admission, a family meeting is facilitated and the entire treatment staff engaged in the patient's care to understand the goals of admission, set expectations, provide details on the patient's condition, and discuss treatments and therapies. The team also discusses what to expect after discharge. Another family meeting is held typically two weeks prior to discharge. Before the patient goes home, clinicians assess the comfort level of all the aspects of care the family may be providing. Having family members trained on care tasks prior to discharge allows them to practice with support of staff before they arrive at home.

Family education is integral to every therapy session every day that the patient is on the TBI unit. And that education continues in follow-up visits, and at outpatient appointments down the road, or as may be the case in the future, by leveraging technology. One of the therapists in the TBI program is applying for a grant to use telemedicine to follow patients at home and communicate with families directly. As many patients that

are discharged are still in a minimally conscious state, thinking about and employing ways to lessen the family burden by cutting down on travel and transports will be immensely beneficial in the long term.

### **Sharing Our Knowledge and Clinical Best Practices**

As a collaborative effort between the Department of Physical Medicine and Rehabilitation, the University of Pittsburgh School of Health and Rehabilitation Sciences, and UPMC Centers for Rehab Services, the UPMC Rehabilitation Institute conducts an annual symposium — Current Concepts in Brain Injury Rehabilitation. The one-day symposium highlights not only patient outcomes, but also clinical work in terms of patient management and therapeutic interventions.

The sixth annual event was held in November 2015, featuring a range of brain injury topics and speakers from UPMC, the University of Pittsburgh, Moss Rehab in Philadelphia, and the Clement J. Zablocki VA Medical Center in Milwaukee, Wisconsin. Many health care workers throughout UPMC and other health

systems will have the opportunity to care for someone who has had a TBI. It may not be every day, but these patients have a specific set of needs. Educating colleagues is crucial for their understanding of what are the best ways to approach these patients throughout the spectrum of their rehabilitative care.

The symposium attracts a broad spectrum of clinicians including those who work in the ICU caring for individuals before they make their way to rehabilitation. The symposium offers health care workers a real focus on what they can do in the early days of treatment to help set up patients for success during their rehabilitative course, and in their long-term recovery. The course further explains what happens to patients once they arrive at the rehabilitation unit because frontline caregivers are speaking to families and can advise them on what the TBI program is able to do, and what they and the patient can expect. Understanding and creating realistic expectations for patients and families is one of the most difficult things to do and this symposium helps to address this aspect of communication.

For clinicians on the outpatient side of the care spectrum, it's about understanding everything that has happened before the patient is discharged home. Helping them contextualize what has happened, and showing them how far the patient has come during acute rehabilitation is very important. Sharing the expertise they have so that other clinicians are comfortable treating, evaluating, and recommending options for patients who have had brain injuries can help prepare families for transitions and future care.

### Translating Research Into Practice

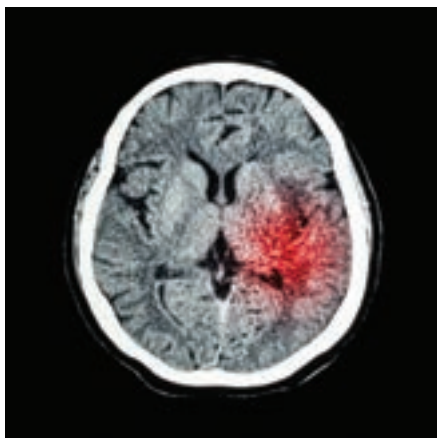
The depth and breadth of the TBI research led by Dr. Wagner cuts across numerous areas of inquiry. While her research portfolio is broad, there is a singular purpose to the work: improve patient care and recovery. Her current work involves investigations into the concept and application of Rehabilomics, a biomarkers based approach to understanding rehabilitation outcomes; she is applying this framework to study dopamine systems and inflammation in TBI recovery, posttraumatic epilepsy, and the development of mental health complications post-injury.

### Rehabilomics — A Personalized Medicine Approach to Understanding and Treating TBI

Dr. Wagner is a leading proponent and researcher in the emerging field of Rehabilomics, a term which she developed in 2010 for this framework which applies a biopsychosocial rubric to understanding functional recovery. "The Rehabilomics concept as we've framed it really allows us to use biomarkers to learn more about the chronic pathology and underlying pathophysiological mechanisms for the types of conditions and complications that we see in clinic every day," says Dr. Wagner.

The Rehabilomics concept is part of a larger personal biology picture emerging on different fronts of medical care. Dr. Wagner believes that, "A key in understanding the Rehabilomics concept is the actual rehab piece. We want to link personal biology to the complications and conditions that people are dealing with post-TBI, but then be able to use this information, in aggregate, to understand downstream outcomes like participation, quality of life, and function. This framework goes a step beyond what others are doing in personal biology with other populations."

As investigators like Dr. Wagner probe deeper and deeper into the complexities of TBI, research points to these injuries and their long-term consequences, “as a chronic disease rather than a static insult from which limited recovery occurs.”



Understanding the progression of TBIs in this way — and layering this knowledge inside the Rehabilomics concept — leads to additional paths to pursue.

As relates to recovery trajectories, the interest lies in not just a reduction of disease burden, but also in understanding of the functional impairments that come out of the disease burden, and how the

impairments affect activities, participation with social roles, and other factors. “By examining the viability of using biomarkers for early patient prognostication, we have been able to understand what the chances of a good recovery might look like overall for a particular patient. We also look at bio-susceptibility to complications associated with TBI. We are beginning to recognize that TBI isn’t just an acute injury, especially for a more moderate to severely injured patient. It’s not a transient problem from which one can expect a full recovery, but rather the start of a process that leads to chronic diseases and illness,” indicates Dr. Wagner.

In relation to chronic disease, there are additional factors emerging from her research that are leading to new investigations. “Our characterization of chronic inflammation, hormone and neurotrophin deficits, has given us a sense of what the underlying substrates relevant to long-term complications and disabilities may be. The longer-term vision is to be able to, with a good understanding and characterization of these processes from a personal biology perspective, leverage that information to

guide treatment. This biomarker-based approach to treatment may be specific to clinical interventions like a medication, but it also may be relevant to the tracking and triage of clinical decisions for the most effective care within a specific pathway,” says Dr. Wagner.

### **Chronic Inflammation as a Mediator of Long-Term Complications and Conditions**

The complexities of TBIs require numerous avenues of research, all related, to piece together the entire disability perspective for patients. From bio-susceptibility and pathophysiology perspectives, Dr. Wagner’s research includes investigations into the roles of inflammation in TBI, and their relation to depression and cognitive dysfunction. Dr. Wagner says that the study of inflammation in TBI patients is becoming increasingly more important. “You may have individuals with significant behavioral problems who are at exceedingly high risk for depression and suicidality. We’re working to determine how chronic inflammation that is initiated by the brain injury itself becomes a biological contributor to mental health problems over the long-term. Recent research suggests that inflammatory cascades

can be perpetuated for years after an insult. I think the ongoing inflammatory consequences of brain injury have been underappreciated, but other literature along with our work helps support the notion that chronic inflammation has the potential to cause some serious complications.”

As investigative efforts continue, Dr. Wagner and her colleagues are beginning to implicate inflammation not just in depression, but in cognitive dysfunction, behavioral changes, neuroendocrine dysfunction, and posttraumatic epilepsy development. “We have examples across all of these areas where inflammation plays a role. The commonalities observed to date suggest that chronic inflammation could really be a broad underlying risk construct for chronic disease after TBI,” she says.

### **The Role of Dopamine Systems in Long-Term Recovery**

The genetics underlying the dopamine system, and how this system functions in an injured brain also appears to be significant in terms of cognitive and behavioral recovery. “We are building a body of evidence suggesting that functional polymorphisms, as well as some novel dopamine system

polymorphisms, contribute significantly to the degree of overall cognitive deficits commonly observed long term after TBI. These polymorphisms (or genetic risk variants) facilitate impaired dopamine neurotransmission, a state that our work with animal models of TBI suggests contributes to cognitive deficits.” Dr. Wagner’s work also implicates dopamine system genetics, particularly among those who already have post-traumatic depression, as contributing to problematic behaviors such as impulsivity and poor decision-making. Animal research being conducted by Dr. Wagner at the Safar Center for Resuscitation Research at the University of Pittsburgh is exploring how dopamine systems respond differently to a traumatic brain injury versus a brain injury that occurs after cardiac arrest. “Our work at the Safar Center is evaluating how dopamine systems respond differently to a TBI versus a brain injury that occurs after cardiac arrest. And what’s interesting about that is with the advent and adoption of hypothermia for early treatment of cardiac arrest, we are seeing more people who survive their cardiac incident but have some type or degree of brain injury and need rehabilitation. This rehabilitation

population is not one we have typically treated in previous years,” says Dr. Wagner.

Dr. Wagner’s animal research is working with the some of the same models used in hypothermia and cardiac arrest research at the Safar Center. “We are using these models to evaluate, and compare and contrast, how dopamine systems are affected. This research has some potential to impact how we treat patients and how we utilize neurostimulants and other classes of medications to raise the level of arousal and participation that these patients can bring to their recovery trajectory,” she says.

Dr. Wagner’s research also has a focus in developing an experimental model of cognitive rehabilitation. “We are using our animal model of traumatic brain injury in interesting ways. We think this cognitive and behavioral learning and memory perspective has some direct relevance to how cognitive rehabilitation therapists work with individuals with TBI, and may be useful in understanding how dopamine agents like neurostimulants might enhance the beneficial effects of cognitive rehabilitation,” says Dr. Wagner. ■

# Brain-Computer Interface Research: Achieving 10 Degrees of Freedom

For rehabilitation patients sometimes progress or success is measured in steps taken. Sometimes it's being able to tie one's own shoelaces again: a lost function is regained with the help of expert clinicians and perseverance. For individuals with spinal cord injuries and paralysis, and for a team of UPMC and University of Pittsburgh researchers, progress and success is measured in degrees of freedom. While research continues to seek cures for spinal cord paralysis, and clinicians and bioengineers work to develop and perfect new and novel adaptive technologies, ground-breaking work is being conducted with neural prosthetics that may one day translate into everyday adaptive devices that can be used to augment current rehabilitation therapies and even restore certain functions to improve quality of life for those with paralysis.

Highly collaborative Brain-Computer Interface (BCI) research using both electrocorticography (ECoG) and intracortical microelectrode arrays (MEAs) has shown exciting and significant advances over the last five years in studies with people with upper limb paralysis. Funded through several entities including the Defense Advanced Research Project Agency (DARPA), National Institutes of Health (NIH), U.S. Department of Veterans Affairs, and the UPMC Rehabilitation Institute, the research team demonstrated — for the first time — brain control of a robotic arm with 10 degrees of freedom by a person with tetraplegia. (*Ten-Dimensional Anthropomorphic Arm Control in a Human*

*Brain-Machine Interface: Difficulties, Solutions, and Limitations*. J. Neural Eng. 12 (2015) 016011 (17pp)). These 10 degrees of freedom allowed the study participant to move the arm in space, orient the wrist, and shape the hand into many different postures in order to perform a number of tasks that involve reaching and grasping.

### **Foundations and Collaboration**

Building on the basic science research in nonhuman primate animal models from Andy Schwartz, PhD, professor, Department of Neurobiology, as well as ECoG studies in patients in epilepsy monitoring units (EMUs), the BCI research team first conducted a short-term, 29-day study (August 2011) in a person with spinal cord

injury using an implanted ECoG device on the surface of the brain to control computer cursors and robotic limbs. This study, led by Wei Wang, MD, PhD (formerly with the Department of Physical Medicine and Rehabilitation), was conducted with a 30-year-old man with tetraplegia and served as a precursor to a longer, more ambitious trial using intracortical microelectrode arrays to capture detailed neural activity to enable control of an upper limb prostheses.

“In 2012 we began our investigation of the intracortical microelectrode arrays with our first volunteer, Jan Scheuermann,” says Jennifer Collinger, PhD, assistant professor, Department of Physical Medicine and Rehabilitation, and a senior investigator in the research.



The team's approach with the intracortical arrays has been different than other groups working with similar technologies. "We are trying to demonstrate a high degree of freedom control of the hand and arm. Our goal is to really move that forward. We were the first group to implant two arrays in the motor cortex and that was based on Andy's (Schwartz) experience working with non-human primates to figure out how many neuronal signals we needed to obtain the desired level of control," says Dr. Collinger.

To be successful, a key aspect of this type of labor-intensive research is participant commitment.

"I'm surprised how committed our participants have been. Jan came in three days a week for four hours a day, for two and a half years. Jan and her attendant, Karina, committed a significant amount of their week to help us with this research and I think having that much time to work with our participant really contributed to our success," says Dr. Collinger.

### **Methodology, Learnings, and Adjustments**

At the outset of the study, the patient was implanted with two 96-electrode MEAs strategically placed in the left motor cortex, based on brain mapping conducted

with functional MRI prior to the surgery. Elizabeth Tyler-Kabara, MD, PhD, associate professor, Department of Neurological Surgery, and a co-investigator in the research, performed the implantation procedure on Jan.

Several complex calibration paradigms were devised to tune the system to the participant's control, allowing for simultaneous and natural control of the robotic hand and arm. "Based on Dr. Schwartz's past non-human primate research, we expected Jan to be able to control the robotic arm, but the pace at which we were able to get there was

faster than expected and was a good surprise for the team," says Dr. Collinger.

Moving through free space, Jan was able to control the prosthetic hand and all the different degrees of freedom very well. However, when she tried to interact with objects, her brain activity changed in ways the team did not anticipate.

"For example, when Jan was near an object, she couldn't close her hand. When she moved away, she could close it," says Dr. Collinger. "Although the exact behavior varied from day to day, we consistently noticed that Jan's control degraded as she tried to pick up an object."





To accommodate for the difference, the researchers adjusted the calibration process by having the participant interact with objects in a virtual environment. “This helped mitigate the problem, but did not remove it completely. We looked at the data and found that as she was approaching an object and issuing a grasp command, all of the neurons that we were recording from were increasing their firing rates. We were able to account for that in an engineering-fashion by scaling the neuronal data that we were getting in real time as compared to what we observed during the training process. It was fixable, but we’d like to understand more about why we saw this change in brain activity when interacting with objects,” says Dr. Collinger.

As their published findings state, “This study demonstrates, for the first time, BCI control of an anthropomorphic prosthetic arm that includes continuous control of multiple dimensions of hand shape. This success was based on the observation that context affects performance, specifically the presence of physical objects as targets, and we found it important to include these in the calibration paradigm. The results generated with this subject greatly extend the sophistication of previous BCI demonstrations and show that highly

coordinated, natural arm and hand movement can be restored to people with upper limb paralysis.” (*J. Neural Eng.* 12(2015))

### **A Research Team Built on Collaboration and Freedom**

The BCI research team consists of partners and collaborators from the University of Pittsburgh departments of Physical Medicine and Rehabilitation, Neurological Surgery, Neurobiology, Bioengineering, Occupational Therapy, Psychology, and Anesthesiology. “This is a pretty unique scenario. Every time I go to a meeting and talk about how our lab is structured people are surprised that we have such a large group of investigators working on this,” says Dr. Collinger. (For further reading see the paper: Collaborative Approach in the Development of High-Performance Brain-Computer Interfaces for a Neuroprosthetic Arm: Translation from Animal Models to Human Control. Collinger et al. *Clin Transl Sci.* 2014 Feb;7(1):52-9.)

“Our team, through its collective efforts, has achieved 10 degrees of freedom of control and the next closest group has two and a half. This was enabled by the incredible teamwork that is possible at UPMC and the University of Pittsburgh:

the partnership between the basic scientist Andy Schwartz, the brilliant engineer Jen Collinger, and Elizabeth Tyler-Kabara’s skill as a neurosurgeon. The work of everyone on this project has been exemplary, collaborative, and focused,” says Michael Boninger, MD, director, UPMC Rehabilitation Institute, and professor and UPMC Endowed Chair in the Department of Physical Medicine and Rehabilitation.

### **What Lies Ahead?**

BCI research is an ongoing project, with another participant currently enrolled in the trial. “We continue to broaden and deepen our research and are moving closer to new function and more freedom with our latest study,” says Dr. Boninger. Future research may involve the use of a bi-direction electrode system that could provide the BCI user with sensory feedback from the robotic arm. The research teams expects that the addition of sensory feedback could further extend the capabilities of the BCI, enabling more natural function of the upper limb. ■

# New Directions in Outpatient Rehabilitation

UPMC provides outpatient care to a growing contingent of patients in numerous locations. Physiatrists, therapists, and a host of other clinical specialties treat patients for brain injuries, pain management, spinal cord injury, stroke, musculoskeletal pain, and other debilitating conditions. For individuals who underwent inpatient rehabilitation at one of the UPMC Rehabilitation Institute locations, the outpatient clinics provide a high degree of continuity of care that facilitates the ongoing rehabilitation process months, and at times years, in to the future. In addition, UPMC welcomes new patients into their various outpatient settings for all of their rehabilitation needs.

Megan Cortazzo, MD, vice clinical chair for outpatient services, and Gwendolyn Sowa, MD, PhD, associate professor and incoming chair of the Department of Physical Medicine and Rehabilitation, are spearheading a number of initiatives in outpatient treatment and rehabilitation research. Their goal is to reshape the care of musculoskeletal patients and further the understanding and translation of biochemical and molecular markers research to develop new, personalized modes and methods of care.

## **UPMC Total Care – Musculoskeletal Health**

Developed and implemented by Dr. Sowa from her research and clinical practice, and launched in July 2015, UPMC Total Care – Musculoskeletal Health is a comprehensive, multidisciplinary outpatient center that uses the patient centered medical home model to treat patients who have a variety of musculoskeletal conditions and accompanying pain.

The clinic takes an individualized approach to patient assessment and care plans, and seeks to remove the barriers that patients

have in recovery, particularly for low back pain, but in all musculoskeletal conditions. The nature of the clinic and comprehensive treatment approach provides for a more efficient level of care, while at the same time decreasing over-diagnosis and over-utilization of services. Patients are assessed and treated for all potential contributing factors such as anxiety and depression, nutrition, obesity, inactivity, and sleep problems, all of which may prevent a patient from achieving an optimal recovery and maintaining their quality of life. “The model of our clinic fits within the evolving model of total care

that UPMC is developing. We’re starting to look at this for other types of diagnoses, and because costs for musculoskeletal care continue to rise while outcomes remain suboptimal, it made sense to focus our attention here,” says Dr. Sowa.

“The concept is something that’s been thought about for a long time in musculoskeletal care. The difference now is we have a perfect storm in our changing health care environment in which quality and patient-reported outcomes are more valued, making this approach timely.

Increasingly, in the scientific literature, we are seeing subgroups of patients with different phenotypes that respond to different types of treatment. Applying a one-size-fits-all approach to care no longer makes sense scientifically or clinically," says Dr. Sowa.

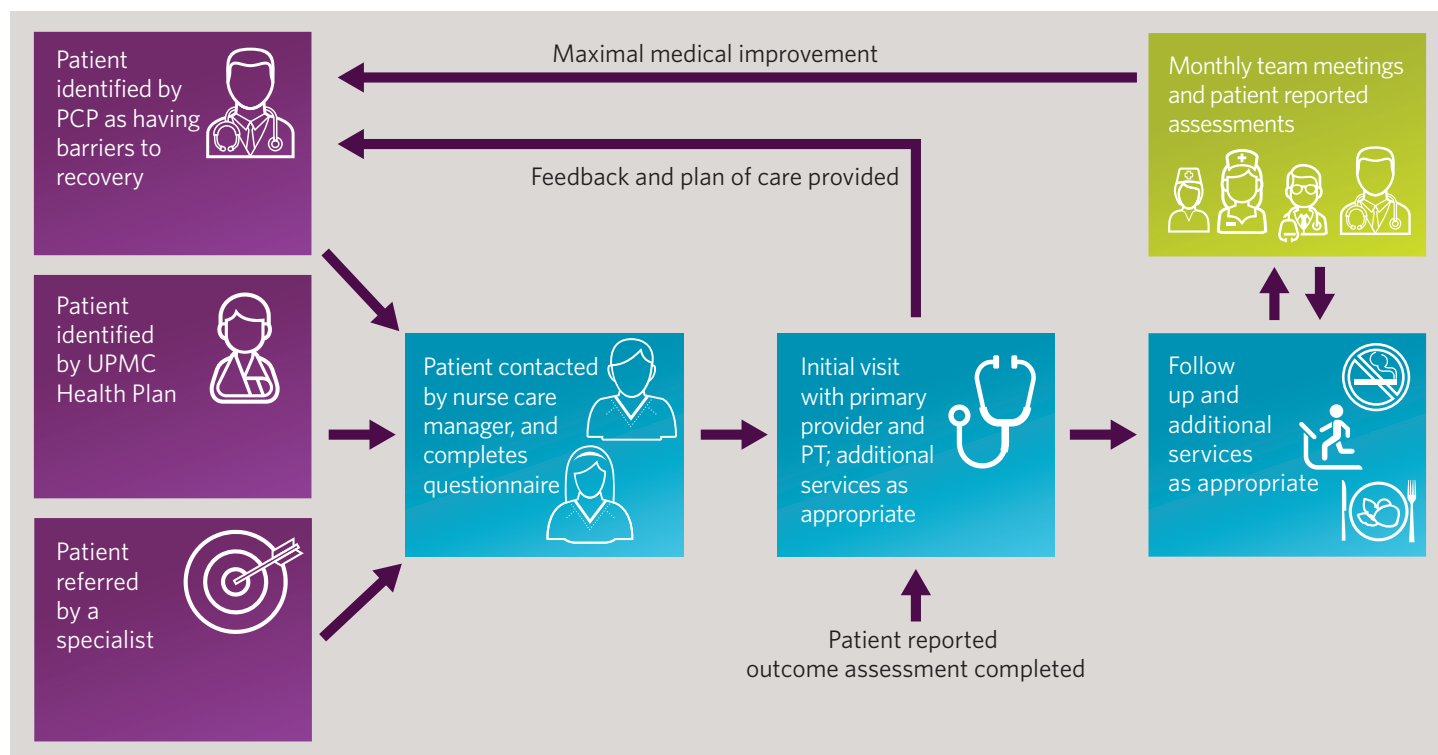
"The idea for this clinic belongs to Dr. Sowa. Over the years, we had talked a lot about how beneficial it would be to see the patients together with therapy and have systemic support built in for other aspects of patient care, for example psychology and nutrition, says Dr. Cortazzo.


In her discussions with primary care physicians (PCPs), Dr. Cortazzo has found that there is a great need for this type of clinic for patients who have musculoskeletal issues, back pain, herniated discs, shoulder or knee complaints, and the like. "We all know these individuals need therapy, that they need to lose weight, that a lot of these patients need psychological support. We also are seeing patients with acute herniated discs and other subacute conditions. We are getting them plugged in to what they need and I think the team approach of the clinic helps them a lot," says Dr. Cortazzo.

### Model of Care

The clinic is focused on identifying the major barriers to recovery for a patient and intervening in an aggressive manner. The services built into the program reflect the experience of the clinical staff. They are designed to address all of the known barriers to recovery from musculoskeletal conditions and were strategically chosen based on what is currently known in the literature to be common comorbidities.

Patients can be referred to the clinic through a number of pathways, however most are currently referred by their PCP as well as our partners in orthopaedic surgery and





**“We can model information to help predict which patients may benefit the most from a particular therapy.”**

*-Megan Cortazzo, MD*

neurosurgery. After the initial referral, patients are contacted by phone for an initial intake with a questionnaire designed to identify the key barriers that the patient may have or likely experience. Subsequently, the initial clinic visit includes a full assessment with a physician and physical therapist, in addition to the patient completing questionnaires about their pain and function. Following assessment and analysis, the patient's plan of care is developed and visits with others specialists are scheduled accordingly based on the patient's specific needs. The clinic notifies the patient's PCP about the plan of care they have developed, if any surgery is recommended, and if there are any complications.

During treatment, monthly care team meetings occur to discuss the patient's progress, collect follow-up metrics, and if necessary, recommend or refer the patient for additional interventions or support services based on their needs.

The intent is to see these patients as soon as possible, for example, after an injury or during the subacute phase of recovery, and focus on the specifics of the care they need. "If it's a patient with a herniated disc, they see the physician along with a physical therapist who has specialty training in disc herniations and back disorders so we can develop a program specific to their condition. The same process is in place for other types of injuries or conditions. And then if they need help with nutrition or

psychological support, we facilitate those services," says Dr. Cortazzo.

### **The Biggest Need**

For many of the patients seen in clinic, the biggest unmet need is for psychological support. Pain certainly affects their mood, personal interactions, and social functioning, but mood dysfunction can also further affect pain. This reciprocity between pain and mood can lead to significant issues. "Our patients' anxiety sometimes feed into the pain itself, making it worse. We discuss with these patients how important it is to manage both aspects of their condition. The message to patients is that there is an interaction between pain and mood, and we help them understand that the neurochemicals involved in pain and mood are similar and overlapping. There's a very real connection between mood and pain, so it's important for us to treat both simultaneously to get a good recovery," says Dr. Sowa.

### **Which Patients Can Benefit the Most?**

For Dr. Sowa, perhaps the most important factor for successful intervention is a motivated patient. Many of the issues confounding successful treatment are necessary lifestyle and behavioral modifications. Patients seeking a more passive treatment approach will most likely not be successful in the program. "Our center does not focus on chronic pain management, but rather we are geared toward reactivating the patient. We work synergistically with our chronic

pain center, and some of their patients are more appropriate for our program, and some of our patients are more appropriate for their program. I think the important prerequisite for a patient coming into our program is that they are ready to make some of the challenging changes they need. We have a lot of support staff to help them, but the necessary first step has to be on their own," says Dr. Sowa.

### **Change and Growth**

Even though the clinic has been operational for less than a year, changes and adaptations have occurred to address feedback from referring physicians. "We've made adjustments in terms of how we communicate back to the PCPs, how we discharge patients back to their PCPs, and we facilitate referrals to our surgical colleagues when necessary. We've designed our services to provide a resource for PCPs. Our goal is to address their musculoskeletal condition, and work in collaboration with the patient's PCP to improve their patient's health care. The feedback we've received so far is that the referring physicians are very happy to have this kind of support for their patients," says Dr. Sowa.

### **Improving Patient Data Capture and Outcomes Measures**

For the last several years, Dr. Cortazzo has led a pilot project in two of the outpatient clinics to change how patients complete admissions and follow-up forms. Employing a tablet computer system, patients enter

information into the device, and that data is immediately available in their electronic medical record. As with any large IT transformation process, there are a number of challenges to overcome.

Dr. Cortazzo explains that for low back pain patients, they currently collect the Oswestry Disability Index, but there have been some glitches. “We realized that some of our patients who are improving no longer select back pain during follow-up visits, so we’re not collecting repeat Oswestry’s. That’s a problem when you want to track pain progression over a long period of time, as well as make comparisons in treatment regimens relative to the condition. At the Total Care clinic, patient scores are being collected, but on paper. Eventually we will be able to roll out the electronic data capture system and make it a seamless process,” says Dr. Cortazzo.

Collecting patient data electronically (and over time) is immediately helpful for clinicians during patient visits. What often happens with pain is that a patient is in excruciating pain during an initial visit, and the clinician does whatever he or she thinks necessary to help alleviate the distress. When they come back for follow-up, still in pain, their perception can be that they are not getting better. “We can say ‘look, when you initially came in you indicated you were severely disabled, now you are only mildly disabled. Although you are still in pain, your function is improving.’ Sometimes it’s helpful just

for that immediate discussion to show them that they are making progress,” says Dr. Cortazzo.

In the future, the data collected on patients and their treatment approaches, and correlating progression, will help guide clinicians as they develop plans of care for patients. “For example, if a patient comes in with an acute herniated disc and physical therapy improves their condition better than an injection did, we can model that information to help predict which patients may benefit the most from a particular treatment,” says Dr. Cortazzo.

### **Research to Inform Individualizing Care for Low Back Pain**

Motion, activity, and exercise: they keep the body and its constituent parts operational. In certain circumstances too much is traumatic and gives way to injury and illness. But one thing is clear: stop moving altogether and the system begins to collapse.

As is generally understood, sedentary behavior and weight gain can foster a pro-inflammatory condition within the body. Conversely, it is known that motion can produce a systemic anti-inflammatory response with potentially beneficial attributes for patients with a condition that results in acute or chronic pain. However, not all patients will respond similarly to a given treatment or therapy. Some types of motion may be beneficial, while others may exhibit detrimental effects, depending upon a number of patient-specific factors.

For many patients: “The key is managing their pain to the degree that they can become more active, as well as educating them about what is pain that can be accepted versus pain that is a warning sign to heed. This is important because some patients will be fearful of movement and think they may make their condition and pain worse. The truth is it’s quite the opposite. The more we get patients moving, the better they feel even though we are not necessarily changing their anatomy,” says Dr. Sowa.

To move toward an individualized approach to care for low back pain, Dr. Sowa’s basic science investigations are studying the beneficial and detrimental effects of mechanical loading on intervertebral disc tissue in the spine, and the role of biomarkers in understanding patient biology as it relates to response to treatment.

### **Tracing the Role of Mechanical Loads on Intervertebral Disc Tissues**

Basic science studies by Dr. Sowa and colleagues that look at the biochemical mechanisms and effects of mechanical loads placed on intervertebral disc tissues have shown several interesting findings in both healthy and degenerated tissues. These findings and ongoing research may one day help to inform and tailor therapy regimens and dosing of therapeutic techniques to achieve an optimal outcome for patients with intervertebral disc conditions and accompanying pain.



Gwendolyn Sowa, MD, PhD,  
associate professor and incoming  
chair, Department of Physical  
Medicine and Rehabilitation



As Dr. Sowa indicates, there is clinical evidence which suggests that certain mechanical loads can have beneficial or harmful effects on tissues relative to several influencing factors. Her recent studies (Sowa GA, Coelho JP, Vo NV, Bedison R, Chiao A, Davies C, Studer RK, Kang JD. Determination of Annulus Fibrosus Cell Response to Tensile Strain as a Function of Duration, Magnitude and Frequency. *J Orthop. Res.* 2011 Aug;29(8):1275-83.) have examined, at the cellular level, the effects of mechanical loads on intervertebral disc tissue in relation to the duration, magnitude, and frequency of the loading conditions. "When we look at loading of disc tissue, we see there are threshold effects. More is not necessarily better. There are

threshold effects with magnitude and frequency, but perhaps the most profound effect we saw in our study was with the duration of loading," says Dr. Sowa.

Using annulus fibrosus disc tissues, cultured both with and without an inflammatory agent, Dr. Sowa's experiments subjected the cells to a variety of mechanical loads modulated by frequency, magnitude, and duration. Inflammatory and catabolic responses as well as effects on extracellular matrix were measured. The experiments showed beneficial effects to the tissues with the application of, "[M]oderate applied tensile strain at slow frequencies, especially when disc cells experience inflammatory stress. The most anti-catabolic effect was observed at low frequency (0.1 Hz) and moderate magnitude (6%) of applied strain."

When the same loading regimen (magnitude and frequency of the stimulus) that showed benefits to the tissues in terms of anti-catabolic and anti-inflammatory effects for a short period of time was extended for a longer duration, the reverse occurred. The cellular tissue began to exhibit pro-inflammatory and pro-catabolic effects. "Duration of loading is one of the most important variables in modulating a beneficial or harmful effect on tissue at the cellular level," says Dr. Sowa.

Beneficial effects of mechanical stimulation were also reduced when higher magnitudes and frequencies of the loads were applied.

"In vitro data confirms that a biochemical mechanism is involved in the response of the tissues to various levels of applied tensile strain, in addition to any material properties of the tissue itself. This may help to explain the differential benefit and, at times, inconclusive results of motion-based therapies. It also suggests that greater attention should be paid to dosing both magnitudes and durations of exercise."

### **The Response of Degenerated Intervertebral Disc Tissues to Mechanical Stress**

While healthy intervertebral disc tissues appear to respond favorably to mechanical stresses, within certain ranges for frequency, magnitude, and duration, additional studies by Dr. Sowa point to different thresholds for degenerative disc tissues (Cells From Degenerative Intervertebral Discs Demonstrate Unfavorable Responses to Mechanical and Inflammatory Stimuli: A Pilot Study. *Am J Phys Med Rehabil* 2012;91:846Y 855).

In this study, the annulus fibrosus tissues, this time from degenerative discs, were subjected to similar inflammatory and mechanical stimuli to gauge response. "The same level of loading that was beneficial for normal tissue was not beneficial for degenerative tissue," says Dr. Sowa.

The degenerative tissues subjected to inflammatory and mechanical stress showed, "a more pro-inflammatory response" and a "decreased expression of catabolic and anabolic genes."



“These results point to the need to titrate therapies based on a person’s own individual level of degeneration. Additionally, an analysis of molecular biomarkers that can give us more detailed information about a patient’s own biology can help us phenotype, or subcategorize, patients into different groups to create more specificity in the clinical care we provide,” says Dr. Sowa.

### **Translational Research: The Role of Biomarkers in Understanding Low Back Pain**

Dr. Sowa is heavily involved in the study of molecular and cellular processes and biomarkers as pathways to understanding various conditions such as low back pain. One day, use of this information will ultimately be used to predict and potentially guide individualized patient care and therapy. Dr. Sowa and her colleagues have published on the subject and have three ongoing studies investigating biomarkers as predictors of success in both injection-type and exercise-based therapies. “Our biomarker research is changing our understanding of molecular processes and how they can not only tell us how a patient is currently doing, but perhaps more importantly predict and guide the best treatment for each individual,” says Dr. Sowa.

One recently completed and published study to understand the relationship of certain serum biomarkers to low back pain in older adults compared to MRI

scans shows interesting findings. Dr. Sowa’s study, *Associations of Serum Biomarkers with Pain and Pain Related Disability in Older Adults with Low Back Pain: A Pilot Study* (Sowa GA, Perera S, Bechara B, Agarwal V, Boardman J, Huang W, Camacho-Soto A, Vo N, Kang J, Weiner D. *Associations of Serum Biomarkers with Pain and Pain Related Function in Older Adults with Low Back Pain: A Pilot Study*. *Journal of the American Geriatrics Society*. 2014 62(11):2047-55) specifically investigated E-selectin, RANTES, TIMP-1, CTX-II, CS846, and NPY biomarkers from patients enrolled in the study, as well as lumbar MRI scans.

While MRI scans provide important information about anatomy, when it comes to intervertebral disc degeneration and accompanying pain, there is often a lack of correlation between what is seen on MRI in terms of degeneration and pain the patient may be experiencing. As Dr. Sowa explains in the report, “Despite limitations of current imaging modalities, correct identification of pain generators is critical to guiding appropriate and successful treatment. This is of paramount concern in the aging population, in whom multiple pain generators frequently co-exist. Nevertheless, interventions are frequently planned based on imaging studies, often resulting in unnecessary procedures and associated morbidity.”

“The most important message from our study is that even though the biomarkers didn’t correlate perfectly with a patient’s

pain and pain-related disability, they correlated better than MRI which has been the gold standard. This suggests that these molecular biomarkers play an important role, in conjunction with other patient assessment tools, in understanding the patient’s condition and guiding therapy,” says Dr. Sowa.

Future research will need to examine a broader range of potential biomarkers. “In this study, when we combined some of the biomarkers into mini-panels, we saw a greater association with the patient’s symptoms than when any one biomarker was examined alone,” says Dr. Sowa. This finding is informing her future research toward not just a single biomarker for back pain, but a panel of biomarkers that may help subcategorize patients. “The more recent studies we’ve undertaken are following the biomarkers in patients that are receiving different types of treatments and evaluating whether the biomarker is associated with their response to treatment, what the baseline biomarker is, and what is the change in that biomarker in response to treatment to give us insight into the biological mechanisms at play. This is some of the work we’re currently doing in the lab,” says Dr. Sowa.

All of these approaches to patient care – multidisciplinary treatment, EHR-based patient data collection, and molecular biomarkers – will allow for a more individualized approach in order to realize improved outcomes for patients with musculoskeletal conditions. ■

# Patient Outcomes

## Rehab Units

### All Patients

Key Outcome Indicators	UPMC Rehabilitation Institute	Nation (Acuity-Adjusted)	
Number of patients	4,161		
FIM change per day	2.60	2.23	Higher is better
Average admission FIM™	54.3	58.0	Lower = more complex
Average discharge FIM	85.4	84.8	Higher is better
Average FIM change	31.1	26.8	Higher is better
Discharge to community	72%	72%	Higher is better
ALOS (days)	14.4	14.5	

The FIM™ instrument is a measure of disability. The scale measures the ability to carry out an activity independently, against the need for assistance from another person or device. Lower FIM scores mean greater dependence.

The need for assistance, or burden of care, translates to the time and energy that another person must expend to serve the needs of the disabled individual so that they can achieve and maintain a certain quality of life.

The FIM instrument measures the following domains:

- Self-care
- Bladder/bowel management
- Transfers
- Mobility/locomotion
- Cognition

### Stroke Patients Only

Key Outcome Indicators	UPMC Rehabilitation Institute	Nation (Acuity-Adjusted)	
Number of patients	1,153		
FIM change per day	2.30	1.88	Higher is better
Average admission FIM	48.4	52.4	Lower = more complex
Average discharge FIM	78.9	78.6	Higher is better
Average FIM change	30.5	26.2	Higher is better
Discharge to community	65%	66%	Higher is better
ALOS (days)	16.2	16.6	

## Brain Injury Patients Only (traumatic and nontraumatic)

Key Outcome Indicators	UPMC Rehabilitation Institute at UPMC Mercy	Nation (Acuity-Adjusted)	
Number of patients	345		
Case mix index	1.60	1.25	Higher = more complex
FIM change per day	2.71	2.14	Higher is better
Average admission FIM	40.5	48.5	Lower = more complex
Average discharge FIM	73.1	75.9	Higher is better
Average FIM change	32.6	29	Higher is better
Discharge to community	67%	67%	Higher is better
ALOS (days)	16.6	15.4	

### Case mix index

The acuity level of patients

### FIM change per day

Average FIM change per day

### Average admission FIM

Total score for all FIM categories at time of admission

### Average discharge FIM

Total score for all FIM categories at time of discharge

### Average FIM change

Difference between admission and discharge FIM scores

### Discharge to community

Percentage of patients discharged to their homes

### ALOS

Average length of stay for patients in this impairment category

Source: UDSMR®

Time frame: July 1, 2014 to June 30, 2015

## Spinal Cord Injury Patients Only (traumatic and nontraumatic)

Key Outcome Indicators	UPMC Rehabilitation Institute at UPMC Mercy	Nation (Acuity-Adjusted)	
Number of patients	262		
Case mix index	1.87	1.44	Higher = more complex
FIM change per day	2.04	1.72	Higher is better
Average admission FIM	50.6	54.5	Lower = more complex
Average discharge FIM	82.7	80.4	Higher is better
Average FIM change	32.1	25.9	Higher is better
Discharge to community	70%	66%	Higher is better
ALOS (days)	20.4	20.1	

# Faculty/Staff Listings

## **Acupuncture**

Betty Liu, MD

## **Concussion**

Maria Twichell, MD

## **Cancer Rehabilitation**

Maryanne Henderson, DO

## **Center for Assistive Technology**

Michael Boninger, MD

Brad Dicianno, MD, MS

Betty Liu, MD

## **Electromyography**

Alan Chu, MD

Kerry DeLuca, MD

Stephanie Giammittorio, MD

Wendy Helkowski, MD

Hejab Imteyaz, MD, MPH

Julie Lanphere, DO

Michael Munin, MD

## **General Rehabilitation**

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## **Neuropsychology and Rehabilitation Psychology**

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## **Pediatric Neuropsychology**

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## **Pediatric Rehabilitation**

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## **Regenerative Medicine**

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## **Research Faculty**

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### **Spasticity**

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### **Spinal Cord Injury**

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### **Sports and Spine Medicine**

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### **Traumatic Brain Injury**

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## 2015 Year In Review

### **About UPMC**

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