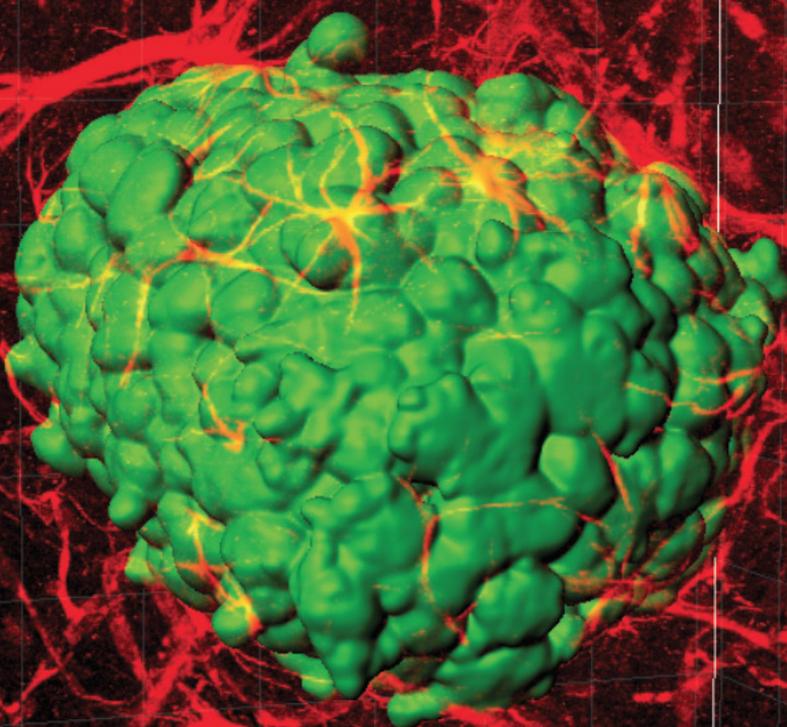


Vol 8 Spring 2017

SCIENTIA

Undergraduate Journal of Scientific Research
University of Notre Dame



UNIVERSITY OF
NOTRE DAME

College of Science



CHARLES EDISON FUND

A LETTER FROM DEAN GALVIN



Undergraduate research is an important component of students' education and vital in preparing them for graduate school or medical school. Through research, they learn what being a scientist really means. Research affords them the joy and excitement of experiencing discovery, of realizing that they are the first to conceive of something new. We are delighted that, through the gracious support of donors, we are able to provide the funding that allows us to make undergraduate research a priority for the College of Science. With this experience, students can capitalize on opportunities to author scientific publications and travel to conferences to present their research results to other scientists.

Scientia is a tremendous outlet for documenting and sharing the thrilling discoveries our undergraduates have made. This publication allows them to develop critical skills for writing about their scientific discoveries. It also promotes interdisciplinary learning, including how to communicate their research results to scientists from other disciplines. This is a skill that will serve our students well throughout their lives.

I am especially proud of this issue of *Scientia*, which contains exciting articles and news on important research and activities in the College of Science. The articles reflect the mission of the University of Notre Dame and cover topics ranging from the impact of the loss of coarse habitat around lakes to caring for patients with sickle cell anemia in Uganda. The students also report on such concerns as the unique approach that Notre Dame is taking to fight the spread of Zika virus; finding a cure for Niemann-Pick Type C; and hosting the inaugural regional conference for the Association for Women in Science-Notre Dame. It is my great honor to be part of this college and to support *Scientia*.

Yours in Notre Dame,

Mary Galvin, Ph.D.
William K. Warren Foundation Dean of the College of Science
Professor of Chemistry and Biochemistry

Editors-in-Chief
Luke Maillie Daniel Pape

Managing Editors
Elizabeth McGough Candice Park
Physics Mathematics
Brandon Roach, Section Editor Justin Skycak, Section Editor
Michael Foley, Junior Section Editor
Kaitlin Salyer, Junior Section Editor News
Sarah Cate Baker, Section Editor

Biology Layout, Design, & Publishing
Candice Park, Section Editor Grace Reilly, Section Editor
Patrick Donegan Madelene McKenzie
Matthew McGoldrick Rose Ellen Crisman
Michael Sokolowski Eric Sah

Chemistry and Biochemistry Health
Jackson Howell, Section Editor Elizabeth McGough, Section Editor
Patrick Donegan
Michael Sokolowski

Photo Credits
Matthew Cashore, Barbara Johnston, Peter Ringenberg, Elizabeth Wildenhain



Acknowledgments: *Scientia*, comprised exclusively of undergraduate work, is sincerely thankful to the students who have submitted their research. Additionally, the editorial board expresses its gratitude for the dedication and guidance of Dominic Chaloner, Ph.D., our faculty advisor; Dean Mary Galvin, Ph.D., for her inspiration, enthusiasm, and support for our mission; Tammi Freehling and Lotta Barnes for helping us through the publication process; and the College of Science and the Charles Edison Fund for their financial support.

FROM THE EDITORS

The University of Notre Dame's College of Science maintains a firm commitment to fostering advancements that solve the world's most difficult and enduring questions. Scientific research is at the forefront of methods to answer these questions. To explore and advance science, the college's faculty and staff work tirelessly to create an environment that encourages independent thinking, exploration, discovery, and collaboration among undergraduate students. Undergraduate research is an essential component for cultivating these skills, and students across all disciplines in the College of Science tackle challenging problems through undergraduate research. *Scientia* is entirely run by undergraduates. For us, *Scientia* embodies our belief that we as students must work alongside of the college to create such an environment. We strive to promote scientific research among undergraduates through the annual publication of our journal, which we are happy to present to you here. In this issue, you will find research ranging from the effect of habitat on the catchability of largemouth bass to studies on health care access for sickle cell anemia and breast cancer in Uganda and the United States, respectively. We also support scientific discourse through our monthly talk series, "Talk Science," and you will find a summary of the 2016-2017 seminars within the journal.

In addition, we are excited to launch the Charles Edison Fund Fellowship this spring. The fellowship funds two students that, due to financial circumstances, are unable to fully commit themselves to research because of their need to seek employment. The funding lasts for two academic semesters and aims to replace the time students work during the academic year to support their education with time spent conducting research. This fellowship conveys our belief that all students should have the opportunity to fully engage in research. Thanks to the help of the College of Science and generous support of the Charles Edison Fund, we are coming close to realizing our vision of a more equitable research culture here at Notre Dame.

In this vein, we encourage undergraduates in all disciplines to get involved in research by diving into their fields of interest. Asking novel questions and developing a sense of curiosity are the beginnings to groundbreaking scientific discoveries. Faculty in the College of Science and across the University are eager to find motivated undergraduate researchers who share their passion. For those who do not know where to start, there are countless opportunities for students to learn about scientific research on campus. Attending seminar series and poster sessions are excellent ways for undergraduates to discover research opportunities. We hope that all students will take the opportunity to explore and participate in undergraduate research.

We would like to end by saying thank you to the people that have been foundational to *Scientia's* efforts. First and foremost, without Professor Dom Chaloner, none of this would be possible. His unwavering support and advice helped us not only to produce this journal, but also ensure that our ideas were put into action. Secondly, we thank Dean Galvin and the entire College of Science's Dean's Office, whose encouragement and direction enabled us to continue to grow and improve as an organization. Finally, we would be remiss to not thank our incredible undergraduate staff, the driving force behind this publication. We leave the direction of *Scientia* to Elizabeth McGough and Candice Park for the coming academic year. Elizabeth and Candice became involved as freshmen and have held numerous leadership roles within the journal. We are confident *Scientia* will see continued success and growth.

In Notre Dame,

Luke Maillie

Daniel Pape
Scientia Editors-in-Chief



CONTENTS

NEWS

- 4 College of Science New Faculty Spotlight
Patrick Donegan, Sarah Fracci, Madelene McKenzie, Carolina Sanchez, and Brady Stiller
- 6 College of Science Promotes Ethical Leaders in STEM
Teresa Kaza
- 7 Flourish3D: Flowers for a Cause
Rose Ellen Chrisman
- 7 Perkins Lab Launches Fight Against Zika Virus
Kathleen Davin
- 8 Fighting Irish Expand Into Online Education
Vaishali Nayak
- 9 Notre Dame Association for Women in Science Hosts Inaugural Conference
Kara Miecznikowski
- 10 Notre Dame Chemists Develop NPC Drug
Rachel Lombard
- 11 QuarkNet Spreads Physics Education Around the World
Mati Namera
- 12 Undergraduates Follow Darwin's Footsteps with Trip to Galápagos Island
Charley Jang
- 13 New McCourtney Hall Emphasizes Interdisciplinary Research
Michael Sokolowski

ON THE FRONT & BACK COVERS ▶

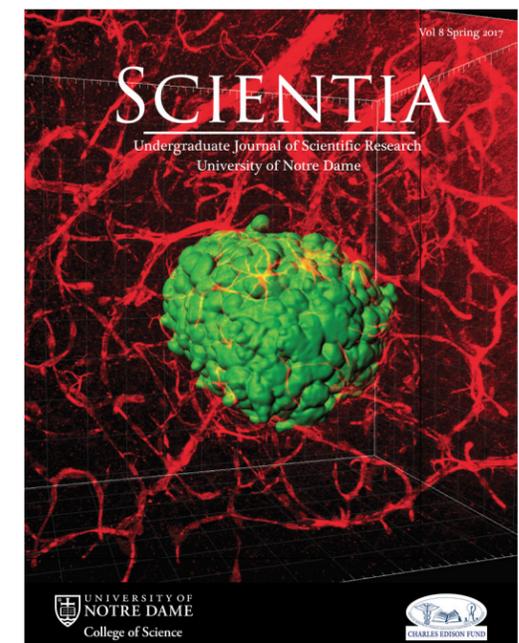
A breast cancer metastasis (green) in the brain forms a secondary tumor and induces the growth of blood vessels (red) in a mouse. In response, native astrocytes induce gliosis (shown on back cover), an inflammatory response, in an attempt to combat the tumor. Despite this response, breast cancer can also metastasize to bones, the liver, and the lungs, highlighting the importance of detecting breast cancer early. Ryan Middleton's article (p. 19) analyzes the Affordable Care Act's efforts to improve early breast cancer detection and patient survival. These images were produced by graduate student Ian Guldner in the lab of Dr. Siyuan Zhang, M.D., Ph.D.

HEALTH

- 15 "The Help Never Reaches Us" A Study of Uganda's Foremost Sickle Cell Clinic
Matthew Weyenberg
- 19 The Effects of the Affordable Care Act on Breast Cancer Survival Rates
Ryan Middleton

BIOLOGY

- 23 Catchability of largemouth bass (*Micropterus salmoides*) on coarse woody habitat in a Northern USA temperate lake
Elizabeth Wildenhain



College of Science New Faculty Spotlight

PATRICK DONEGAN, SARAH FRACCI, MADELENE MCKENZIE, CAROLINA SANCHEZ, BRADY STILLER



Jessica Brown, Ph.D., Assistant Professor of Chemistry and Biochemistry, earned her B.S. at Wright State University, and her Ph.D. at The Ohio State University. She completed her post-doctoral fellowship at Yale University and the Howard Hughes Medical Institute. Brown uses RNA biochemistry and X-ray crystallography to study the triple helix structure at the 3' end of long non-coding RNAs. Of particular interest is the way in which its lack of degradation can cause cancer. The goal of her research is to better understand the biology, chemistry, physical nature, and structure of such RNA triple helices, especially MALAT1, associated with lung carcinoma. Brown is dedicated to undergraduate participation and is a strong believer in the importance of diversity at any level in this field. The Department of Chemistry and Biochemistry is glad to welcome Brown to the College of Science, and she is likewise excited to grow and expand the mission of Notre Dame's dedication to the sciences through her teaching and research.



David Medvigy, Ph.D., Associate Professor of Biological Sciences, received his B.S. in physics at Rutgers University and his Ph.D. in applied physics at Harvard University. After completing his postdoctoral work at Duke University, Medvigy spent seven years as a faculty member at Princeton focusing on research, teaching, and advising students. During his time

there, he enjoyed working with several dozen undergraduate students, whose projects focused on how vegetation will respond to climate change in the future, and how vegetation currently affects the climate. Medvigy cites the quality of the faculty and students, as well as the conducive environment with similar research, as reasons for his move to Notre Dame. At the University, his research focuses on terrestrial ecosystems and climate change, and specifically why and how trees grow. His research investigates the constraints on tree productivity; how tree growth is limited by water and nutrients, how rates of tree growth respond to climate change; and how, given that they store excessive carbon, terrestrial ecosystems impact atmospheric carbon dioxide and climate change. Medvigy says that his lab has many opportunities for undergraduates, including research projects with potential for publications and conference presentations. Students in his lab will develop a model of a critical ecosystem processes, then use the model to understand why real ecosystems behave the way they do and how they may change as climate changes in the future.



Graham Peaslee, Ph.D., Professor of Experimental Nuclear Physics and General Physics for Students in the Health Professions, received his A.B. in chemistry from Princeton University and his Ph.D. in chemical physics from Stony Brook University. Formerly involved in teaching and working with undergraduate researchers at Hope College, his background is in nuclear science, chemistry, physics, environmental science, and astrophysics. To date, he has produced 183 scientific publications, 56 of which include 159 undergraduates as coauthors. This high level of co-authorship with undergraduates is a testament to his view of students as vital to his research. Peaslee's research involves a continued effort to apply his experience with nuclear science to the pressing issue of sustainability with regard to hazardous chemicals in the environment. His efforts include innovative approaches to measuring PFOA and PFOS, which are prevalent man-made environmental toxins contained within many mundane items such as textiles and food wrappers. He also works to raise awareness of the prevalence of these hazardous chemicals in manufactured products. Peaslee strives to incorporate undergraduate and graduate students alike in his mission to apply a knowledge of chemistry and physics to these ethical issues.



Andrew Putman, Ph.D., Professor of Mathematics, earned a B.A. in mathematics at Rice University before earning his Ph.D. in mathematics at the University of Chicago. Prior to Notre Dame, Putman worked as a postdoctoral fellow at the Mathematical Sciences Research Institute in Berkeley and served as a C.L.E. Moore Instructor at the Massachusetts Institute of Technology for three years. He was a faculty member at Rice University for six years. The presence of family in the Midwest and strong research ties to Chicago brought Putman to the University, and he says his favorite aspects of Notre Dame so far are the intellectual atmosphere and collegial nature of the mathematics department. He teaches a mixture of undergraduate and graduate courses. This year, he taught Calculus II and the more advanced Basic Geometry and Topology. Putman's research interests include the interactions between geometry, topology, and algebra, with a special focus on the geometry of moduli spaces. Recent honors include a Séminaire Bourbaki lecture on his work, a Sloan Research Fellowship, and a National Science Foundation CAREER award. Putman's recent published papers include "The codimension-one cohomology of $SL_n\mathbb{Z}$," (*Geometry and Topology*) and "Representation stability and finite linear groups" (*Duke Mathematical Journal*).



Marco Radeschi, Ph.D., Assistant Professor of Mathematics, earned his B.A. at the Polytechnic University of Turin and M.A. from the University of Turin in Italy. He went on to earn his Ph.D. from the University of Pennsylvania and completed his postdoctoral fellowship in Germany. Radeschi's research focuses on various aspects of geometry, specifically understanding the behavior of geodesics in special manifolds, all of whose geodesics are closed. (Geodesics are curved lines used to minimize the distance between two points.) Recently Radeschi has been interested in Classical Invariant Theory, in order to extend the results to the set up of singular Riemannian foliations. Radeschi is looking forward to collaborations across the math department and the opportunity to get more involved with undergraduates next semester as he begins his time as a faculty member at Notre Dame.



Daniele Schiavazzi, Ph.D., Assistant Professor of Applied and Computational Mathematics and Statistics, earned his B.S. and M.S. in Structural Engineering from the Università degli Studi di Padova, Italy. After a few years in Australia and Italy working as an engineering consultant, he returned to his alma mater to pursue his Ph.D. in applied mathematics and

subsequently complete his doctoral thesis as a visiting researcher at Stanford University. He also completed his postdoctoral fellowships at the University of California, San Diego and Stanford University before joining the faculty at the University of Notre Dame. Here at Notre Dame, his research focuses on theoretical and applied work in stochastic modeling, including the efficient solution of direct and inverse problems in uncertainty analysis. His main field of application is predictive hemodynamic modeling and how this can complement clinical decision-making by quantifying confidence in personalized response to cardiovascular therapies. This research spans a wide range of disciplines, including computational mechanics, deterministic and stochastic differential equations, and cardiovascular physiology, and it aims to include diverse contributions from willing undergraduate and graduate researchers. Schiavazzi teaches both graduate and undergraduate level courses including Stochastic Analysis (Spring 2017) and Introduction to Stochastic Modeling (Fall 2016). His awards and accomplishments include a Laurea Summa Cum Laude in Structural Engineering and an American Heart Association Postdoctoral Fellowship. When listing his favorite parts about the University thus far, Schiavazzi cites the warm sense of community at Notre Dame, the quality of the students, and the University's focus on being as a world-class research institution and a global force for good.



Christopher Schommer-Pries, Ph.D., Assistant Professor of Mathematics, received his B.S. in mathematics from Harvey Mudd College and his Ph.D. from the University of California, Berkeley. A recipient of the National Science Foundation Postdoctoral Research Fellowship and other prizes and grants, he spent time at Harvard and MIT as a postdoctoral researcher. During his four years prior to joining the Notre Dame community, Schommer-Pries conducted research at the Max-Planck Institute for Mathematics in Germany while teaching classes there. Along with Notre Dame's welcoming community and expanding studies in particular mathematical areas, his research interests in topology, higher category theory, and quantum field theory have led him to his new home under the Golden Dome. These diverse interests are relevant to many other subjects in physics and mathematics, and these fields have contributed to many modern advances. While at Notre Dame, Schommer-Pries continues to study mathematics by classifying certain quantum field theories. Many breakthroughs have occurred within the past 30 years in this topological field study, including a recent physics Nobel Prize. The author of several publications on topology and field studies, Schommer-Pries is looking to incorporate undergraduates into his research within these developing fields.



Cody Smith, Ph.D., Elizabeth and Michael Gallagher Assistant Professor of Biological Sciences, received his B.S. in biology at Mercyhurst University and his Ph.D. in cell and developmental biology at Vanderbilt University. At Notre Dame, he now studies the development and regeneration of the nervous system, researching how cells organize and how

a normally functioning nervous system assembles compared to diseased state. As an undergraduate, Smith found his passion for creating time-lapse movies, which earned him an Excellence in Microscopy Award. Using the zebrafish model, his lab members mount a specimen on a coverslip and cover it in agar to hold it still for periods longer than 24 hours. Technological advances have improved his resolution from an image once every 15 minutes to once every 15 seconds. With this time scale, one can see the development of cells within the nervous system as they move through it. Professor Smith's lab also has the ability to create lesions in the animal during microscopy, ablating single branches of the nervous system with a laser and observing how the cut axons respond to injury and regrow. All of this research has the common goal of improving understanding of diseases such as multiple sclerosis, spinal cord injury, and Charcot-Marie-Tooth disease, the most common inherited neurological disorder. Attracted to Notre Dame by its energetic, high caliber scientists, Smith now has the opportunity to fulfill his passion for training enthusiastic graduate and undergraduate students.

College of Science Promotes Ethical Leaders in STEM

TERESA KAZA

The opportunity to discuss particular ethical issues associated with serving as a leader in STEM fields in the University's Ethical Leaders in STEM program (EL-STEM) caught Sarah Lum's attention. Lum is a current participant in EL-STEM, a program in the Notre Dame Graduate School intended to develop leadership and communication skills, in addition to self-awareness, in third- and fourth-year Notre Dame graduate students to ethical problems in science. "You really get to talk about some of the issues that occur in your day-to-day lives that aren't topics typically discussed or addressed head on in any other environment," Lum said. The program is now in its second year. According to faculty adviser John Lubker, M.S., Ed.D, the program's goal is "to have someone who maybe is a leader or thinks they want to lead and help them process the question: What really matters?"

EL-STEM is funded by a grant from the National Science Foundation that supports training programs on ethical issues for graduate students. According to its website, EL-STEM's aim is to "provide an opportunity to become aware and further develop one's leadership strengths, to provide an ethical foundation for decision-making, and to positively impact the community." During the year-long program, EL-STEM students participate in seminars, all-day workshops, and an experiential leadership opportunity, in addition to receiving a \$1,400 stipend for their time commitment.

The experiential leadership component gives EL-STEM participants the chance to practice the skills they develop from the workshops and seminars. "The goal of that practicum is to have an impact on their community and hopefully continue that impact when they're finished," Lubker said.

Lum is applying the knowledge she gained from EL-STEM to her leadership role as a career counselor at the Crossing, an alternative South Bend high school which gives students a second chance at obtaining a degree. Lum, who had tutored at the school previously, designed a program to prepare high school students for college. She brought in college counselors and organized a FAFSA night to help students achieve their goals of pursuing an advanced degree.

Other students chose to apply their knowledge from the program to leadership roles within the University. Andrew Bartolini, a fourth-year civil and environmental engineering and earth sciences Ph.D. student, completed the EL-STEM program last year and is now applying the skills he learned to his teaching and mentorship positions. One concept Bartolini derived from the program was the "no excuses policy," a leadership approach described by Russell Lowry Hart, Ph.D., president of Amarillo College in Texas, during an EL-STEM seminar. "Amarillo College had a graduation rate below 20 percent when Lowry

Hart took over," Bartolini recalled. "Lowry Hart explained how he embraced a 'no excuses policy' where he would create a path for all students to graduate. In embracing this policy, he has started the process of systematically eliminating all barriers that prevent students from graduating. He has set an ambitious goal of achieving a graduation rate of 70 percent by 2020." Bartolini is applying Hart's concept as he designs a workshop intended to teach spatial reasoning skills to engineering students. Bartolini hopes his workshop will help bridge the gap between male and female engineering students by "eliminat[ing] a potential barrier to student success."

Although only in its second year, EL-STEM has made a tremendous impact on students. "The program is ideal for someone who is interested in having meaningful conversation about issues that matter in a safe and encouraging environment," Lum said. "EL-STEM is also a place that fosters accountability for a leadership growth project where you can actually practice these skillsets in your daily or weekly routine."

Cate Flanley, a third-year integrated biomedical sciences student and current participant in the program, agrees. "EL-STEM made me think about how I interact with colleagues, students, and administrators. It helped me adjust my approach from a place of judgment to really listening and leading with compassion and empathy. The program also helped identify my blind spots, or weaknesses, and [created] a comfortable place to examine them and formulate a path for improvement."

For Bartolini, the most powerful takeaway from the program was how it developed his understanding of leadership as service: "If you lead by serving and listening, you're on the road to leading ethically. In reference to the 'no excuses policy,' leading is truly serving your constituents by eliminating all barriers that they may face in the road to success. A leader has the responsibility to serve in a moral and ethical manner, in order to enable success for those they lead and their organization."

All components of the EL-STEM program tie into its vision of sending graduate students into their fields as servant leaders. Following training, students will hopefully apply their training and heightened understanding of themselves in and out of the workplace according to the values of the University. "I've been blown away by the amount of passion, persistence, and time these participants have put into their practicum," Lubker said. "We need leaders in STEM fields, and this program would be a good experience for anyone who wants to have an impact on their community or their field. The program will help them discover their potential to do just that."

For more information on the EL-STEM program, visit graduateschool.nd.edu/professional_development/ethics/ethical-leaders/.

Flourish3D: Flowers for a Cause

ROSE ELLEN CHRISMAN

Something is blooming in Notre Dame's Integrated Imaging Facility—but do not worry about your spring allergies, because these are not real flowers. Aislinn Betts, a junior science-business major in the lab of Matthew Leevy, Ph.D., is turning flowers into crystals for the new social venture, Flourish3D. Describing the story behind the name of the company, Betts said, "We all brainstormed ideas and we discovered that the biggest thing was that we wanted to combine the flower aspect with the 3D science-side of it. We wanted to keep it positive and tie it back to our whole purpose."

Flourish3D focuses on serving people—not only do lab members create crystallized flowers via clinical CT scanners and laser engravers, but the final products are gifted to immunocompromised cancer patients at Memorial Hospital and beyond. Before Flourish3D bloomed into the successful entrepreneurial venture it is today, it began with imaging equipment experimentation on flowers taken from around Notre Dame's campus. "The scanned flowers turned out beautifully, and so when my sister remembered that one of our family friends was not able to receive flowers while she was undergoing chemotherapy, we set everything up and got the products made," Betts said. The lab currently has four flowers on the market, all collected from landmark locations around Notre Dame's campus: Roses are taken in front of the stadium, cone flowers in front of Galvin Life Sciences Building, geraniums around the Dome, and Canna Lilies gathered between the Basilica and the Grotto. The flower crystals have names that reflect their beauty and hope, such as the Onward to Victory Rose and Cone Flowers for a Cure.

With spring right around the corner, the Flourish3D team is excited about the new flowers they will be able to scan. The tulip, an iconic Notre Dame flower, will be soon added to the collection. Since its germination, Flourish3D has accomplished so much that the nonprofit has expanded to Saint Mary's College, University of Illinois, and Miami University of Ohio. In addition, Flourish3D could become an approved student organization and broaden its reach. The flowers are available for purchase online and at Martin's Supermarket, which has sent the special product to more than 20 stores in the area.

Flourish3D is at the intersection of service, science, entrepreneurship, and business. Sarah Chapman, a member of Leevy Lab, said "much of the support for [Flourish3D] is from the University. We got a lot of interest from Notre Dame research and Harper Cancer Institute, as well as the University's Engineering, Science, and Technology Entrepreneurship Excellence Master's Program (ESTEEM). In the past, there was science and business, and they didn't really overlap much. But now, it seems like everything is a little bit business, including the science."

Betts and Chapman both see Flourish3D as so much more than the hours spent compiling data files and communicating with the industrial manufacturer; it is about the impact they are making in the lives of others who are experiencing profound hardship. "For someone who recently lost someone, it's a nice sentimental gift," Betts said. Adding to her statement, Chapman said, "Sometimes we conduct research for so many years that we get caught up in our data and our experiments. Our focus is not necessarily the person on the other side of the bench. For me, Flourish3D is exciting because it brings our research back into real life. We're doing this for people, not just to get published and produce data. There's a real human element to it."

So, the next time you walk to class, remember to stop and smell the roses -- you never know who else may be appreciating that same flower.



Currently, Flourish3D offers four different types of flowers: Geraniums, Cone Flowers, Canna Lilies, and Roses.

Perkins Lab Launches Fight Against Zika Virus

KATHLEEN DAVIN

In early 2016, an obscure mosquito-borne virus was brought to the forefront of international news as case after case of Zika virus was reported in Brazil. This under-studied "minor" virus became one of the most pressing contemporary global health concerns and was declared a public health emergency by the World Health Organization in February of 2016. Combatting the spread of Zika is a collaborative effort, and at Notre Dame, Alex Perkins, Ph.D., and his team are on the forefront of this

international fight. However, you won't find any mosquitos in this laboratory; in the Perkins lab, scientists fight Zika with their computers.

Perkins and his team combine mathematical, computational, and statistical approaches to unravel the dynamics of infectious disease spread and management. These diseases, like Zika, are incredibly complex, and understanding their transmission patterns and the factors that underlie them is critical to addressing

the global health threat that they pose. Amir Siraj, Ph.D., a post-doctoral researcher who has made numerous important contributions in the lab, explained how he applies this approach to address the questions that Zika presents:

“Our research focuses on the determinants of Zika virus transmission, including those of environmental, demographic and socio-economic nature. We model the effects of each of these determinants in the context of a highly mobile global, regional and national population,” Siraj said. He works on developing novel approaches to explain the connections between these oft-overlooked factors and attack rate. He starts with current, small-scale situations and uses advanced mathematical and computational methods to apply these disease models on a larger, real-world population scale. Through these analytical approaches, Siraj is able to highlight key relationships between the rates of disease spread and underlying factors, gaining greater insight into the Zika epidemic. Through these analytical approaches, Siraj can estimate well ahead of time the number and location of populations that could be infected with Zika during the course of an epidemic. The timeliness of such results are crucial in guiding policies to counter the epidemic spread before it affects the population.

Previously, mapping these critical relationships was dependent on unreliable case studies that did not accurately represent the observed phenomena of disease transmission. In response, the Perkins lab developed a new method that utilizes highly spatially resolved data about the drivers of Zika transmission, allowing scientists to draw conclusions about how the disease is spreading and hypothesize about what it may do in the future. Their model, published last year in *Nature Microbiology*, projects that 1.1 million infections in childbearing women and 64.2 million infections across all demographic levels in the Americas could occur before the first wave of the epidemic subsides. These projections are an important contribution to efforts to understanding the potential magnitude of the Zika epidemic and offer a new way to make rapid assessments of the threat posed by emerging infectious diseases.



Alex Perkins and Amir Siraj analyze data relating to the various determinants of Zika virus transmission.

Currently, Siraj and the rest of the Perkins team are focusing their efforts on forecasting Zika transmission in South America. The lab is also collaborating with international partners to evaluate potential sites to develop and implement a Zika vaccine to mitigate the virus' spread.

Siraj hopes that the lab's work will aid future research endeavors to continue unravelling the complex relationships between ecological, social, and economic factors and disease spread. At the same time, he notes that “better understanding of the roles of evolutionary forces and large scale climate drivers in the differential effects of Zika outbreaks across continents [is] important.” This improved understanding could improve disease surveillance, diagnosis, and treatment methods to combat the significant threat that the Zika virus poses to global health.

Perkins, Siraj, and their team are only the most recent innovators in the University of Notre Dame's legacy of infectious and mosquito-borne disease research. Scientists at Notre Dame have been intensely studying the biology and impact of disease since the 1950s. In fact, the Eck Institute for Global Health, with which the lab is affiliated, is a global leader in the study of *Aedes aegypti*, the primary vector of Zika. Through their work, the Perkins lab continues Notre Dame's commitment to global health and its record of leading progress in the field.

Fighting Irish Expand into Online Education

VAISHALI NAYAK

In a world where technology affects almost every sphere of daily life, there is a growing need for people who can analyze and make sense of the constant flow of information. Recognizing the rising demand for data scientists across many different industries, the University of Notre Dame entered the world of online education through its new online master of science degree with a specialization in data science. The program, created in collaboration with AT&T, will help prepare graduates for careers as data scientists in a wide range of industry fields such as management, marketing, information technology, government policy, health care, finance, education, and scientific research. AT&T was brought on board through a series of negotiations, led by Elliott Visconsi, Ph.D., chief academic digital officer and assistant provost at Notre Dame.

“The Applied and Computational Mathematics and Statistics

(ACMS) Department and other departments, especially Computer Science and Engineering, and the new Information Technology, Analytics, and Operations from the Mendoza College of Business, are making great strides in training ND undergrads in data science skills. However, the demand is so great that we felt we should also be trying to educate those already in the workforce around the country.” said Steven Buechler, Ph.D., director of the ACMS master's degree program and ACMS professor.

This focus on those already out in the workforce is represented by the program's openness to anyone who has learned calculus and linear algebra, and also has some experience in programing. These requirements can also be met through online classes or classes at local colleges. Also, similar to most online education programs, the 21-month degree program will also be offered at

half-time pace to fit the schedule of working professionals.

This online education platform is unique compared to other online education programs for many reasons. First, due to Notre Dame's characteristic commitment to its students, the curriculum was designed just like an on-campus class and created by a committee of ND faculty from multiple departments. Classes will be offered through 90-minute live sessions to students. Secondly, the program will be integrated deeply with current developments in the field through AT&T's partnership and Silicon Valley Immersion Weekends. AT&T has assisted the program not only through a generous gift that has helped fund course materials, but also through providing access to case examples and datasets that faculty will include in their course materials. The Silicon Valley immersion experience reflects Notre Dame's developing presence in California. A substantial

part of course development will happen in onsite collaboration with the dynamic data science community present there.

In 2017, the program's pilot year, Buechler is expecting a class of 200 applicants that will be narrowed down to a cohort of 40 students. In the following years, he is certain that the program will comfortably manage a class size of 80 students, though he admits that he does not want to expand past 120 students a year.

Through the small classrooms and immersive experiences of the data science master's degree—unheard of for online courses—the Fighting Irish are set to mark their foray into the world of online education for higher learning. It signals not only the deepening of Notre Dame's ties with the tech industry, but also reflects the University's commitment of ensuring that the its focus on the common good will guide the data science workforce of today and tomorrow.

Notre Dame Association for Women in Science Hosts Inaugural Conference

KARA MIECZNIKOWSKI

Since its founding in August 2012, Notre Dame's Association for Women in Science (AWIS-ND) has become an active graduate student group on campus, supporting women in STEM by providing opportunities for networking, professional development, scholarly engagement, and more. Through this support, the Notre Dame Chapter of AWIS strives to ensure that women in STEM fields achieve their full potential. Last fall, the association hosted their first Regional Women in Science Conference for female graduate students in the Midwest.

The two-day inaugural conference took place during the last weekend of September and welcomed more than 100 students from Notre Dame and other regional universities. The conference consisted of several events, including a poster session, networking opportunities, resume reviews, lunch discussions, and an opportunity for participants to present their research. Keynote speakers from the Smithsonian Institute, University of Wisconsin, and the Bureau of Justice Statistics presented their research, and attendees partook in informational and mentoring workshops as well.

In addition to providing opportunities for professional development, the conference allowed attendees to gather and discuss the challenges that women in STEM face. Suzanne Neidhart, a third-year graduate student in the Department of Chemistry and Biochemistry, was the conference director and workshop committee head. “The multifaceted aspect of the conference addressed many of the issues scientists face and created opportunities for students to participate in conversations with top women speakers in the region; who have successfully navigated their career paths in academia, government, and industry. Although I am on the traditional academic career path, I want to provide these opportunities for other graduate students who are pursuing careers in industry and government.”

Participation of faculty and staff was high; many volunteered to assist with discussion panels and conducted resume reviews. “We saw a lot of generosity from many different entities during



The AWIS-ND conference included poster presentations from graduate students.

the planning and operation of the conference,” Neidhart said. “Others are very willing to help, get involved, and give advice—and help us do the same for other women. This an organization in which we are not only trying to help other people, but also growing as leaders in our fields.”

Many of the conference's events were made possible through the funding or direct involvement of on-campus organizations, like the Kaneb Center for Teaching and Learning and Graduate School Career Services, which assisted with the workshops. The support AWIS-ND received from Notre Dame organizations for funding and operating the conference was not unlike the support these groups provide other AWIS-ND events: “Our organization gets a lot of support on campus. Notre Dame's College of Science and Graduate School are two of our largest benefactors. We put on a lot of events throughout the general school year, and the only way we could do that is through the help and funding of those organizations. The success and impact of the Women in Science Conference would not have been possible without the team of female scientists from Notre Dame and the

support from our organization's sponsors who believe in our mission 'to initiate, encourage, and engage women in STEM in a welcoming and supportive environment, creating a sense of belonging within the community and providing opportunities for success.'"

The Notre Dame's Association for Women in Science

helps organize approximately 25 activities on campus each year, including opportunities for professional development, fundraisers for local community organizations, and social and networking events. The association plans to host a Regional Women in Science Conference every other year. For more information, visit awis.nd.edu.

Notre Dame Chemists Develop NPC Drug

RACHEL LOMBARD

When Mike and Cindy Parseghian learned that three of their four children were diagnosed with Niemann Pick Type C disease (NP-C), they knew they had to take action. NP-C disease is a progressive lysosomal storage disease that typically results in death before 20 years of age. NP-C is caused by mutations in either the NPC1 or NPC2 gene, which lead to a shortage of functional protein and an inability to transport cholesterol out of lysosomes. Accumulation of cholesterol leads to many complications, specifically in the brain, causing neurological disease. With few treatment options available, the Parseghians took matters into their own hands by founding the Ara Parseghian Medical Research Foundation.

Launched in 1994, the Ara Parseghian Foundation funds medical research with the hope to someday find a treatment for NP-C. The foundation began this effort by predominantly funding basic research of the mechanisms underlying NP-C. With biological information derived from these studies, Cindy Parseghian brought in chemists to develop drug treatments for the disease. In September 2004, Cindy met with Paul Helquist, Ph.D., and Olaf Wiest, Ph.D., at Notre Dame, where she encouraged them to join in the effort for NP-C treatment.

With Helquist's expertise in chemical synthesis and Wiest's expertise in computational chemistry, the pair made quite the team. Helquist and Wiest agreed to join the fight and attended the annual Michael, Marcia & Christa Parseghian Scientific Conference for NP-C in Tuscon. While at the conference, Wiest and Helquist met Frederick Maxfield from Cornell University. Helquist, Wiest, and Maxfield had the innovative idea to treat NP-C infected cells with histone deacetylase inhibitors (HDACi). A histone deacetylase is a type of enzyme that removes an acetyl group from histone proteins. The removal of acetyl groups allows histones to wrap DNA tighter and thereby repress expression of genes located on that segment of DNA. HDAC inhibitors inhibit these enzymes, which release DNA from histones and activate gene expression. Previously, HDAC inhibitors had been used in the treatment of various cancers.

Helquist, Wiest, and Maxfield took this idea from cancer therapy and applied it as a possible treatment pathway for NP-C. In about 95% of NP-C patients there is a mutation of the NPC1 gene that encodes for a protein involved in the transport of cholesterol out of lysosomes. This mutation results in low levels of the NPC1 protein in NP-C patients, leading to cholesterol accumulation. Helquist and Wiest reasoned that a similar approach to what had been used in cancer could be applied to NP-C, in which HDAC inhibitors could be used to up-regulate NPC1 expression. Helquist and Wiest sent HDAC inhibitors to

Maxfield at Cornell, where he used them to treat fibroblasts with NPC mutations. The cells were imaged and treated with Filipin, which causes cholesterol to fluoresce. Initial results proved promising, as NP-C cells no longer had cholesterol spots and looked indistinguishable from healthy cells after treatment with the HDAC inhibitors.

Initial success guided Helquist, Wiest, and Maxfield into more in-depth research involving HDAC inhibitors and NP-C. A Food and Drug Administration Phase I clinical trial began in September 2014 and was completed in September 2016, led by Forbes Porter at the National Institutes of Health. The purpose of this clinical trial was to assess the safety of one of the HDAC inhibitors identified by Helquist and collaborators on patients with NP-C. The results are currently being compiled and statistically analyzed. Passing safety regulations for use on patients as sick as those with NP-C is especially challenging. If they can show that this particular drug class is safe in patients with NP-C, then the next challenge will be identifying which specific HDAC inhibitor has the best therapeutic effects against NP-C.

In addition to the clinical trial, in May 2016, Helquist, Wiest and Maxfield received a U.S. patent for their therapeutic inhibitors. The patent covers the full spectrum of HDAC inhibitors for treatment in NP-C and other related diseases and credits to Helquist, Wiest, and Maxfield for their innovative use of HDAC inhibitors in the treatment of NP-C. This story is a testimony to what can be accomplished when people from different fields come together for a common good.



Professor Olaf Wiest presents data on NPC1 and NPC2 proteins and how mutations in each disrupt cholesterol transport.

QuarkNet Spreads Physics Education Around the World

MATI NEMERA

A deck of cards and a cosmic ray detector small enough to fit inside a suitcase make for great lessons in particle physics, according to Notre Dame physicist Thomas McCauley, Ph.D. From creating ordering schemes of particles on cards to analyzing cosmic ray data, students engaged in QuarkNet events participate in the physics research process, aided by physics mentors such as McCauley. The lessons and resources provided by McCauley and his colleagues at QuarkNet introduce students to authentic scientific data generated by particle physicists, giving students practical experience with high-level scientific research.

QuarkNet is an organization that provides high school teachers and students resources to explore particle physics. The organization operates in more than 50 centers across the United States, connecting students and teachers to universities and professors actively conducting physics research. Each QuarkNet center has some autonomy regarding its choice of physics activities and programs. Notre Dame's QuarkNet center performs a variety of functions, including offering a summer program where students use scintillators and other physics lab tools to investigate particle phenomena.

However, at its core, QuarkNet is a professional development program for teachers, operating on the notion that engaging one teacher benefits the many students the teacher educates. QuarkNet aims to maximize its impact by supplementing the research experience of those teachers who go on to impart their knowledge to students in a more engaged manner. Teachers participate in data collection and analysis at QuarkNet, and they extend their orientation towards physics research to their students. QuarkNet even occasionally assists teachers in applying for mini-grants to fund physics activities in their classrooms.

QuarkNet's international scope gives students a sense of the collaborative nature of science. The largest research initiatives require the global cooperation of scientists from around the

world, and QuarkNet provides its students with an appreciation of this intellectual interdependence; for example, QuarkNet collaborates with International Particle Physics Outreach Group, Fermilab, European Organization for Nuclear Research (CERN), and TU Dresden to offer day-long masterclasses. During these classes, students from around the world learn about particle physics, statistically analyze data, and discuss their results with each other via videoconference. Additionally, students can examine particle physics data released by CERN, cosmic ray data from detectors, and seismic background data from the Laser Interferometer Gravitational-wave Observatory (LIGO).

McCauley, a Notre Dame researcher, and Kenneth Cecire, a QuarkNet National Staff teacher at Notre Dame, know firsthand the value of QuarkNet's global mission to enrich the physics experience of students and teachers. The pair traveled to Kigali, Rwanda, and Addis Ababa, Ethiopia to teach and talk about particle physics with high school students. Their goal was to expose these students to particle physics and instruct teachers on how to incorporate modern particle physics into their classroom lessons. In Kigali, McCauley, Cecire, and other physicists held a teacher workshop to develop teachers' analytical skills with physics data. Instead of educating students and teachers using textbooks, McCauley and Cecire taught students by having them analyze data from CERN. In Addis Ababa, McCauley and Cecire facilitated the students' and teachers' generation of their own data, helping them assemble a cosmic ray detector to investigate the activity of elementary particles in the atmosphere.

"It is difficult to see how what one is studying in a classroom can apply to what happens at CERN [and the Large Hadron Collider]," observed McCauley. "So the importance for me is to demystify and make more concrete what real physicists do and what they study."

In the future, Mitchell Wayne, Ph.D., a Notre Dame physicist and principal investigator for QuarkNet, would like to see each QuarkNet institution form a closer collaboration with another QuarkNet center as a "sister school." Notre Dame's QuarkNet chapter has already received a grant from Notre Dame International to foster educational particle physics collaboration between Notre Dame and Pontifical Catholic University in Santiago, Chile. Wayne hopes that partnerships like these will become more common and reinforce in students the notion of science as a cooperative endeavor.

Additionally, much of QuarkNet's value comes from exposing high school students to the methodology and mindset necessary for scientific investigation. QuarkNet teachers hope to instill in students an appreciation of basic research and its applications. While the domain of particle physics may seem far removed from the macroscopic world, the fruits of basic research pervade our daily lives. Wayne stressed the importance of basic science research in making possible the technological advancements we may take for granted.

"Go into a doctor's office," Wayne mused. "Everything



High school students work on computer modeling during a Notre Dame QuarkNet summer camp in July 2016.

in there came from basic research. MRI didn't come from a physician knowing how to image soft tissue in the body. It came from attempts to measure the magnetic moment of a proton."

QuarkNet aims to cultivate a love of science in students who participate in its programs. The organization hopes that

exposing them to the performative aspect of scientific research will dispel misconceptions regarding physics research. Through its hands-on approach, QuarkNet may help students from around the world understand that, as Wayne puts it, "science is not just something you learn; it's something you do."

Undergraduates Follow Darwin's Footsteps With Trip to Galápagos Islands

CHARLEY JANG

During the fall break of 2016, a group of 14 students followed in the footsteps of English naturalist Charles Darwin as they embarked on a weeklong trip to the Galápagos Islands. The trip was part of the new Practicum in Field Environmental Biology course, led by Notre Dame professors from the Department of Biological Sciences, Gary Lamberti, Ph.D., and Mac Fraser, Ph.D. According to Fraser, they began this course with the hope that "students and faculty would feel the connection with and excitement of this unique environment where Darwin walked and studied, which helped spark and support the development of the Theory of Evolution by Natural Selection."

The course attracted students from a wide range of majors, including biology, environmental science, physics, science-business, anthropology, and history. "I applied because I think that Theory of Evolution by Natural Selection was one of the, if not *the*, most monumental moments in human history," said junior anthropology major Matthew Williams. "I wanted to go walk where he walked, see what he saw, and rediscover his historic theory. The trip reminded me just how incredible life on earth can be, and I will never again take the beauty that surrounds us for granted."

The Galápagos Islands are an archipelago of about 19 volcanic islands off the coast of Ecuador. Each island boasts distinctive endemic wildlife and a unique landscape, ranging from barren, black volcanic rocks to white sand beaches leading to clear blue waters. Prior to arriving on the Galápagos Islands, students attended classes during the semester on general concepts of evolutionary biology, ecology, and environmental science. Students also gained an understanding of the history and background of the islands, along with lessons on research methods, including developing hypotheses from observations and collecting data to support these hypotheses. When students were not snorkeling and swimming with penguins, sharks, and manta rays, or journeying through lava tunnels and hiking to witness giant tortoises, each student conducted research projects that they developed under Lamberti and Fraser.

Research projects ranged from studying the interactions between the sea lions and humans to the differences between cacti on different islands and the effects of predation on their evolutionary development. "Their research project had to be performed in a completely non-intrusive manner to the plants and animals of the islands, which the students accomplished in creative and instructive ways," said Lamberti.

Williams conducted an observational study on sexual selection in *Butorides sundevalli*, or the Galápagos lava heron,



The class explores St. James Island with Bartolomé Island in the distance. Both islands are volcanic, as shown by the characteristic "rope lava" rock landscape.

in which he argued that sexual selection for phenotypic plasticity in males accelerated the evolutionary adaptation of *B. sundevalli* to a novel habitat. "I wanted to use *B. sundevalli* to better understand how sexual selection could have worked on our own species. There is no doubt that phenotypic plasticity is a central theme in the story of our success, so better understanding how it can contribute to speciation allows us to better understand the story of ourselves," said Williams.

Senior environmental science and anthropology major Hannah Legatzke completed a research project focused on invasive plants in the Galápagos, in which she explored how the various biological, economical, and cultural factors intersected and influenced the introduction and management of invasive species on the islands. "The course offered an amazing opportunity to actually witness and discuss the concepts studied in my biology electives. The Galápagos Islands are a truly amazing example of conservation efforts. The experience heightened my understanding of the ways in which people interact with the environment," said Legatzke.

This course not only benefitted the students who embarked on this trip, but also enriched the lives of students in South Bend. The course included a teaching outreach project with the Robinson Community Learning Center, in which the undergraduates presented information about the Galápagos, prior to, and following, their trip to local elementary, middle, and high school students. These students remained engaged throughout the experience through pictures and daily blogs.

Fraser and Lamberti look forward to furthering this experience, saying, "We hope this course will continue, allowing both faculty and students the opportunity for this unique experience. We feel that this type of course embodies exactly what an ND course should entail—namely, close collaboration among students and the instructors and a 'real' learning experience with active engagement of the study topic. While we currently have one excursion per year allowing 14 students the opportunity, if the demand warrants it, perhaps we could consider as many as two excursions per year."

The professors also noted how significantly this course impacted their careers. "From a teaching standpoint, I have to say that this has been the most rewarding experience of my career," said Fraser. "I was blown away by the excitement and intellectual curiosity of the students during the course,

especially while in the Galápagos. It was particularly gratifying to see the students as they experienced all this for the first time, the wonder and thrill of it all for them." Lamberti concurred, "The close interaction with students, getting to know each other on an intellectual and also personal basis, was marvelous. It was also a fantastic learning experience for the instructors, where the natural environment substituted for a textbook and the students led the way with intriguing research projects."

As the course continues, more students will have the opportunity to follow in the footsteps of Charles Darwin. In doing so, they will experience the same beauty and uniqueness of the ecosystems on these islands that continue to provide insight into our understanding of the Theory of Evolution by Natural Selection and the diversity of life on all corners of our planet.

New McCourtney Hall Emphasizes Interdisciplinary Research

MICHAEL SOKOLOWSKI

In August 2016, the construction of the newest addition to the Notre Dame campus, McCourtney Hall of Molecular Sciences and Engineering, concluded. The \$80 million project brings together the College of Science and College of Engineering in an open and collaborative lab environment, and was enabled by the generous donations of \$35 million from Ted H. McCourtney ('60) and his wife, Tracy, as well as \$10 million from Thomas J. Crotty, Jr. ('80) and his wife, Shari.

The three story, 220,000 square foot building was constructed with the intention of providing a new, world-class research facility for the Department of Chemistry and Biochemistry and the Department of Chemical and Biomolecular Engineering. In addition, according to the University, it is the first building of a larger planned East Campus Research Complex.

The faculty members who moved into McCourtney Hall were previously housed within the Fitzpatrick Hall of Engineering, Stepan Chemistry Hall, or Nieuwland Hall of Science. Peter Kilpatrick, Ph.D., McCloskey Dean of Engineering, told *The Observer* that upgraded utilities were needed in order to make more intensive research possible. In these older buildings, the faculty and students had limited access to large-scale research labs and were unable to conduct experiments requiring more advanced fume hoods.

"We have many faculty members in these departments who did not have adequate modern laboratories," Kilpatrick said. "Much modern chemical engineering and chemistry research requires very ventilation-intensive research [and] the buildings that these two departments are in right now simply do not have adequate air flow and utilities capabilities to accommodate this research. The new McCourtney Hall is much more modern, collaborative and flexible, and it localizes research in the molecular sciences and engineering—all dramatic improvements over the existing spaces."

One of the newly relocated faculty members is Matthew Champion, Ph.D., a research associate professor in the

Department of Chemistry and Biochemistry. Champion employs mass spectrometry to weigh biological molecules, in order to determine their identity, quantity, and size. He utilizes this method to investigate bacterial pathogenesis, where he can weigh the mass of proteins produced by bacteria in an effort to identify their role in disease.

Beyond the updated amenities, Champion stated that perhaps the most significant aspect about McCourtney was its layout. "Where before faculty members would need to travel to different buildings, now they can just come downstairs. In fact, two of my major collaborators are now in-house. One success of the building is the creation of nodes of principal investigators with similar experiences. You know which section to go to for an answer about the piece of science you've been thinking about, instead of having to search people out."

Champion also stated that it was exciting to see the construction of a new scientific research facility, as there have not been many science-focused research spaces built in the last few decades at Notre Dame. He added that another benefit was that the building was not "completely built from the ground up with new people," as a large amount of the building has been populated with both senior and junior faculty. According to Champion, this allows for a "range of level of faculty knowledge and interests."

McCourtney Hall has more than 100,000 square feet of wet lab space, all which have state-of-the-art amenities. The building has an in-house nitrogen supply, allowing the gas to be directly pumped into any lab that requires it. In an effort to encourage collaboration, there are also a number of common spaces, as well as a café. There are conference rooms on each floor which are available for reservation, as well as a seminar room, on the lower level, which can hold approximately 60 people. The lower level also contains a mass spectrometry laboratory.

While parts of the Department of Chemical and Biomolecular Engineering and the Department of Chemistry and Biochemistry

have already moved into the building, the space is not limited to them exclusively. Faculty and students from other departments may be placed in the facility in the future, particularly if they have large research groups or special laboratory needs. Currently, almost half of the building still sits empty.

The facility, while mainly inhabited by faculty and graduate students, also has great potential to aid undergraduates. Senior Barbara Kazanowska, who works in the lab of Ruilan Guo, Ph.D., said the difference between her previous space and McCourtney was night and day. “Our lab in the basement of Fitzpatrick had one room—we had to walk through a neighboring lab to get into a second room. We had a grand total of three fume hoods to work with and eight people in the team. When we moved to McCourtney, everyone got their own hood and their own space. We actually have windows now. It’s an environment more conducive to doing research, and I actually enjoy going to the lab more.” In Kazanowska’s view, McCourtney simply feels much more refined than her previous lab location. She also appreciates the more “collaborative” layout. Before, she would have to trek from the basement of Fitzpatrick Hall to Stepan Hall in order to speak to chemistry faculty, but now, she can simply go upstairs. Kazanowska also stated that because the building is new and completely state-of-the-art, it may incentivize others to get into research, and more importantly, attract others already interested in research to Notre Dame.

When combined with Notre Dame’s stellar researchers, the new McCourtney Hall allows Notre Dame to be more



Graduate student Jennifer Wiegand and Professor Ruilan Guo prepare to run an experiment in their new lab space in McCourtney Hall.

competitive in scientific research by having modern facilities to rival those of other peer institutions. This new construction signifies a clear commitment by the University to bolster its research programs, and greater emphasize STEM majors and courses. With the planned addition of another large wing in the future, McCourtney Hall is just the start.



McCourtney Hall improves interdisciplinary collaboration among researchers by housing faculty from both the College of Science and the College of Engineering. More than two-thirds of the space remains unfilled in anticipation of future hires.

“The Help Never Reaches Us”: A Case Study of Uganda’s Foremost Sickle Cell Clinic

Matthew Weyenberg¹

Advisor: Rev. Robert Dowd, C.S.C.²

¹University of Notre Dame, Department of Preprofessional Studies, ²University of Notre Dame, Department of Political Science

Abstract

Sickle cell disease is a genetic blood disorder that disproportionately affects those of African descent, and its prevalence is extremely high in countries like Uganda. Sickle cell disease is a systemic condition that affects many different areas of the body through oxygen shortages, leading to high mortality rates when undiagnosed and unmanaged. This research explored experiences with sickle cell disease and sought to examine the strengths and challenges of treatment at Uganda’s primary sickle cell clinic. This research was conducted at the Sickle Cell Clinic at Mulago National Referral Hospital in Kampala, Uganda in June and July 2016. Semi-structured in-depth interviews were conducted with 30 patients and caregivers, and seven different healthcare workers from the clinic. The research found that the clinic experiences many of the same resource shortages as its governing hospital, even in important services such as screening or supplying essential drugs. Most parents of patients at the clinic do not know the sickle cell status of their other children because they cannot afford the test. Overall awareness and resources are severely lacking nationwide, partly because sickle cell does not have any of the funds or advocacy that illnesses like HIV receive. While patients must endure resource shortages at the clinic, they prefer to be treated at the specialized clinic over anywhere else. This research raises questions about the allocation of health and educational funding towards prevention and cost-efficient treatment, scaling diagnostic capabilities, and exploring comparative efforts to address sickle cell concerns.

Background

Sickle Cell Disease

Sickle cell disease (SCD) is an inherited, autosomal recessive blood disorder that results in abnormal hemoglobin structure. This produces sickle-shaped red blood cells that carry less oxygen, which can cause many serious health concerns in affected individuals, including anemia symptoms and pain crises. Individuals who are heterozygous for the abnormal gene are asymptomatic carriers and are said to have sickle cell trait (SCT).

Based on the genetics of the disease, an individual with SCD or SCT can only have a child with SCD if his or her partner also has SCD or SCT. This means that effective screening could fully prevent the occurrence of the condition, but more realistically, genetic screening and counseling can educate and

advise. There is a strong case for carrier screening in Africa given that cheap and simple methods exist for testing adults and newborns (1). Knowledge of risk provides a range of options that includes limiting family size and ensuring at-risk infants are tested at birth (1). These screenings and genetic counseling for hemoglobin disorders like SCD are recommended by the World Health Organization as an intrinsic part of health care in most countries (1).

Sickle Cell in Uganda

Uganda has an extremely high prevalence of sickle cell, but the disease remains neglected with little reliable data or political will to improve the situation, despite the associated mortality (2). Some older sources cite the sickle cell gene as being carried by 20 percent of Ugandans and state that 80 percent of those born with SCD in Uganda die before five years of age (3). More recent studies confirm the large burden of sickle cell. A research team, which published this year in *The Lancet Global Health*, conducted hemoglobin testing of around 100,000 infants to investigate the prevalence and distribution of SCT and SCD across Uganda (2). Their data demonstrated an enormous burden, with SCT being present in all 112 districts assessed, an overall SCT prevalence of 13.3 percent, and a prevalence of more than 20 percent in eight districts (2). It is important to note that these findings were based on samples collected on HIV-exposed infants under a robust laboratory “Hub” support system to transport the blood from all regions of Uganda to a central high level facility—this may not be the case when handled separately for the diagnosis of SCD due to limited access of diagnostics.

Mulago Hospital (Kampala, Uganda)

Mulago National Referral Hospital is the largest hospital in Uganda and is also the teaching hospital of the Makerere University College of Health Sciences. The Sickle Cell Clinic (SCC) at Mulago is the oldest and largest care facility for sickle cell anemia in the country. Records suggest that more than 11,000 patients to date have been registered with the clinic and about 5,000 have regularly attended the clinic in the past two years. The adult population accounts for approximately one-third of these patients. The clinic is only open during the daytime Monday-Friday, and is closed on public holidays. The majority of patients at the clinic come from around Kampala.

All services, when resources are available, are offered for free at the clinic. The main exception is the Hemoglobin Electrophoresis test, which is used to screen for, and diagnose sickle cell—the clinic does not have the machine necessary to conduct the experimental analysis and must outsource the tests to the Ugandan Cancer Institute. These tests cost approximately 20,000 Ugandan shillings, or the equivalent of about \$5.50-\$6.00. As one parent cited, “To a Ugandan, that’s a lot of money. Because it can buy food like for 5 times.” (sic)

Methodology

This study employed qualitative methodology to help understand the complexity and nuances behind the issues faced by those affected by sickle cell, as well as to give their experiences a voice. Semi-structured, in-depth interviews were conducted with young Ugandan adults attending the Mulago

Hospital Sickle Cell Clinic as patients and caregivers for pediatric patients, as well as doctors, nurses, and other public health workers attending to these patients. The subjects for this research were obtained through partnership with the Sickle Cell Clinic at Mulago Hospital, with the only requirements being that participants be at least 18 years of age and consent to participate in the study. A total of 37 interviews were conducted: 23 caregivers and seven patients, for a total of 30 individuals attending the clinic, as well as seven of the workers at the clinic. There were two interview prompts: one for the healthcare workers and one for patients and/or caregivers. Prompts included many of the same questions, were largely open-ended, and took approximately 20-25 minutes for patients/caregivers and 30 minutes for workers. This research was conducted during June and July of 2016.

Findings

Knowledge of Sickle Cell

A number of subjects cited common misunderstandings about sickle cell, the most common (8 subjects) being that some people think the illness is the result of witchcraft: “Some people don’t believe that it’s a disease, they believe they are bewitched.” There was also a common sentiment that those with sickle cell would die young; that they would not reach adulthood. Other misunderstandings include mistaken association with HIV/AIDS and accusations of spouses and families: “Marriages can end with separations because sometimes you can get a lot of problems. You get accusations of who gave them sickle cell.” Some social issues that resulted from misunderstanding, included segregation in schools, being treated badly or not welcomed, and being denied jobs.

When asked where people learn about sickle cell, the most common response by far was in hospitals and clinics. The second most common response was Hotel Africana, where a free sickle cell conference is held once a year. Several people cited the media as a source of information, a few said that people learn about it by talking with others, and only two people said it is taught in school (one of whom specifically said schools teach about it in genetics). Twelve subjects explicitly stated that people do not learn about sickle cell in school. These results are summarized in Figure 1.

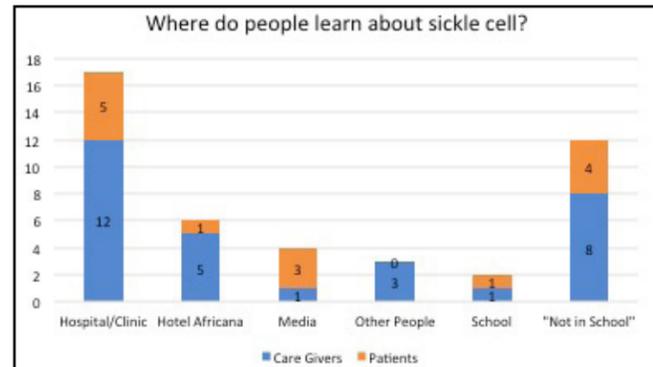


Figure 1. Subjects were asked about where people learn about sickle cell.

Sickle Cell Status: Two-thirds of subjects declared that their family members do not know their own sickle cell status (whether they are carriers or not). If they gave a reason why other family members had not been tested, it was financial—they could not afford the test: “I need to have a test... but it is so expensive... The money I have is for treatment for this one, so I do not have the money.”

Media

Two-thirds of subjects thought it was common for the media to discuss sickle cell, usually over the radio or in the newspaper.

The most commonly cited topics discussed in the media included different drugs and treatment, and directing people where to go for drugs, treatment, events, conferences, etc. Of the cited topics, summarized in Figure 2, the least common were explaining what sickle cell is and discussing testing for sickle cell. It is interesting to note that one of the caregivers and three of the adult patients discussed how they have negative impressions of the media.

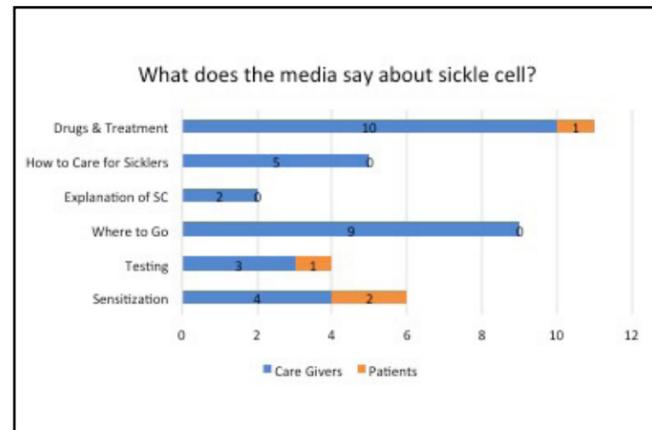


Figure 2. Subjects were asked about what the media says when it discusses sickle cell.

Testing

The pediatric and adult patients were first tested for sickle cell at an average of about two years old. There were two main outliers—one was tested at eight years old, the other at 18 years old. The patient who was tested at 18 knew she had sickle cell earlier because she had similar symptoms to her little brother, who had more severe symptoms and was officially diagnosed while young: “I was first tested when I was 18, at Hotel Africana for free. I didn’t get tested earlier because of the money.”

Approximately 27 percent of subjects thought it is better to test couples, compared to 55 percent of subjects who thought testing people when they are younger is better. Some subjects gave suggestions for how to revise testing/screening practices: “As a child is going into a school, as they ask for the birth certificates, have them ask for sickle cells also;” “The screening should be done like immunization is done.” Another subject elaborated on some notable concerns about testing at a young age: “[Younger] is better. But it is not easy to explain to the children when they are young what that means. And it is not easy to explain to a partner that you were tested when you were young.”

Mulago SCC

Only 40 percent of subjects were aware of other places or organizations that offer testing or treatment, and these individuals were asked if there was a specific reason why they chose to go to Mulago SCC in particular. The primary reason seemed to be money—services at Mulago SCC are free, whereas private clinics are not. As one subject said, “There are private hospitals that treat, but if you don’t have the money then they don’t.” Other reasons mentioned were proximity in location, confidence in the SCC, and because of the facilities. The sentiment was that, “Wherever else you go, they refer you here.”

Group counseling sessions are much more common than individual one-on-one counseling. Some had done both individual and group counseling. Sixteen out of seventeen people thought the counseling was helpful—the one who did not find it helpful was frustrated by the large group setting and said there should be more one-on-one counseling.

When asked where future sickle cell funding should be directed, nearly everyone mentioned aspects of the Mulago SCC that were lacking or that they saw as issues. Several subjects expressed their frustrations with doctors coming in late and leaving them waiting. As can be seen in Figure 3, the largest concern by far is the shortage of drugs. A worker from the pharmacy explained that drugs are often out of stock, and shared some records from the last several days regarding drugs that were actually dispensed versus the total number of drugs prescribed: 71/121 (58.7 percent), 23/45 (51.1 percent), 74/136 (54.4 percent), on three days, respectively. Most of the drug shortages stemmed from drug shortages in Mulago Hospital at large.

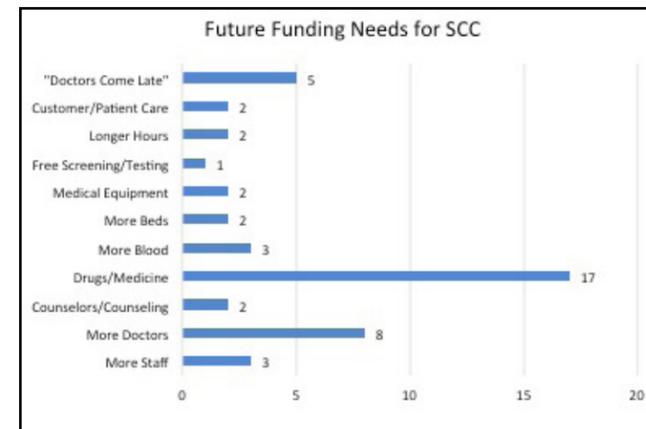


Figure 3. Subjects were asked about where funding should be directed.

Discussion

One of the most noteworthy findings is the role the media plays in regard to knowledge of sickle cell. Two-thirds of subjects responded that it was common for the media, usually radio or newspaper, to discuss sickle cell. This seemingly conflicts with the results concerning where people learn about sickle cell, because only four subjects mentioned the media, in comparison to the 20 subjects who said it is common for the media to talk about sickle cell (Figure 1). The missing insight may be found in the results of what the media says about sickle

cell—the media largely discusses drugs or treatment for sickle cell, or advertises locations of events or places to seek treatment. The media also tries to destigmatize sickle cell, saying that it is a disease rather than some sort of curse. The media even talks about how to care for those with sickle cell, what to feed them, and how to help minimize pain. The topics that the media seems to cover least, however, are testing for sickle cell and providing an explanation of what sickle cell actually is (Figure 2).

The media situation is intriguing because it seems to demonstrate a large degree of untapped potential for spreading sickle cell awareness and promoting testing. The issue may be the current mode of use in terms of media outlets, or perhaps the interests of those who are responsible for sickle cell in the media. Naturally, people would want to advertise special events, and it may be difficult to provide a concise and comprehensive explanation of sickle cell in a brief radio advertisement. The current availability and affordability of testing is a major issue, and likely results in testing only being mentioned when it is free at certain events.

More insight into issues with sickle cell in Uganda may be found in the results of where people learn about sickle cell (Figure 3). The overwhelming response was that people learn about it in hospitals and clinics, and a surprising number of subjects explicitly stated that people do not learn about sickle cell in school. What are the implications of hospitals being the primary source of information? To some extent, it likely showcases the bias of the subjects, who frequent the sickle cell clinic and likely have learned much through their time spent around the clinic. For the subjects of this study, much of what they know about sickle cell did likely come from a hospital setting. Overlooking any bias, a hospital is likely a poor broadcasting system, particularly in a place like Uganda where preventive primary care is more of a luxury that is largely inaccessible to the masses. This, combined with the absence of the topic from a standard educational environment, can be a significant impediment to raising awareness.

While the SCC is a good starting point, it is severely lacking in some areas. The clinic faces many of the same resource shortages as Mulago Hospital at large, and it needs more drugs and doctors. Subjects complained that they rely on the drugs and treatment at the clinic being free—for them to pay for transportation both ways and coming home empty-handed is a waste, because they could have used the transportation money to buy medicine elsewhere. Another restriction of the clinic is that it cannot perform screening or diagnose for free. As a result, essentially no general screening is done at the clinic. The overwhelming majority of these tests serve as confirmatory diagnoses.

Conclusion

There is a great need to improve sickle cell efforts in Uganda, and the foremost SCC should ideally serve as a model and epicenter for necessary change. The clinic’s largest strength may be its free and specialized services that encourage patients to receive care there compared to other locations. This study suggests that one direction forward may be targeting the dissemination of information by taking advantage of untapped potential in raising awareness through schools, the media, and medical facilities.

With this case study of the Mulago SCC, it is important to keep everything in perspective: This is the foremost sickle cell clinic in a country with a very high burden of the disease. It is located in the nation's largest city, operates as a sub-clinic of the largest public hospital, and is affiliated with the top university. Outside of some private clinics, which the poor cannot afford, this clinic leads the way in sickle cell care. At this clinic, there are many barriers to receiving care and it appears that even donations may not extend to patients: "There are a lot of people with lovely hearts who think they are helping, but the help never reaches us." If help does not completely reach those with the opportunity to attend this top clinic, one can imagine the lack of care for those afflicted with sickle cell in the rest of the country.

Acknowledgements

The research advisor Fr. Bob Dowd, for his support in all aspects of the project. Ilaria Schnyder von Wartensee, for her assistance in designing the research and analyzing results.

Mulago Hospital, for its approval, hospitality, and generosity in allowing this research to be conducted. The Mulago Hospital International Office, Dr. Philip Kasirye, and Sister Florence at the Sickle Cell Clinic.

This study was made possible through a Summer Comprehensive Grant provided by the Undergraduate Research Opportunity Program at the University of Notre Dame.

This research was approved by the Institutional Review Board at the University of Notre Dame through a full board review process and by the Mulago Hospital Research and Ethics Committee.

References

1. B. Modell, M. Darlison. *Bull. W.H.O.* 86, 480-487 (2008).
2. G. Ndeezi et al. *Lancet Glob Health* 4.3, 195-200 (2016).
3. *Sickle Cell Uganda*. Sickle Cell Association of Uganda, n.d. Web. 21 Aug. 2015.

About the Author

Matthew Weyenberg is a senior at the University of Notre Dame pursuing a major in Science Preprofessional Studies and a minor in International Development Studies. Matthew first developed interest in this project while spending eight weeks in Jinja, Uganda for an International Summer Service Learning Program (ISSLP) offered through Notre Dame's Center for Social Concerns. During that first summer in Uganda, he encountered sickle cell in the news, at the clinic where he volunteered, and saw the impacts of the disease firsthand in one of his students at school. He intends to pursue a medical career focused on vulnerable and underserved populations.

The Effects of the Affordable Care Act on Breast Cancer Survival Rates

Ryan Middleton¹

Advisor: Allison Malloy²

¹University of Notre Dame, Department of Biological Sciences

²Carmel High School, Carmel, IN

Abstract

Breast cancer is one of the deadliest diseases in the developed world. In response to this public health threat, the Obama Administration attempted to make preventative care and insurance more accessible to the entire American population, as many women were foregoing mammography, a proven method of detecting breast cancer early, and thus improving their chance for survival. The purpose of this paper is to evaluate the effectiveness of the government's solution, the Affordable Care Act (ACA), in decreasing the disease's death rates. In order to do this, the study examines the presence of four dependent variables before and after implementation of the ACA: insurance mix, mammography volumes, average stage of cancer discovery, and death rates.

Introduction

Background

Approximately one in eight women will be diagnosed with invasive breast cancer within her lifetime and preventative care is extremely important to treatment (1). By screening with mammograms, physicians can discover the disease and begin treatment earlier, preventing tumor progression. Despite this, many women forego the tests (2). Two of the strongest predictors of mammogram usage are insurance and socioeconomic status. Reacting to those predictors, President Obama signed the Affordable Care Act (ACA) into law in 2010 to provide better insurance to those with lower socioeconomic status. Section 2713: Coverage of Preventative Health Services will be the focus of this research, as this section of the ACA outlines what preventative medical measures all insurance companies must cover without cost sharing, using the guidelines laid out by the United States Preventive Services Task Force (USPSTF) (3). Included in these preventative measures are cancer screenings. Although several types of mammograms exist, screenings are the focus of this research, as they are used on a regular basis for the undiagnosed population.

An assessment of the ACA and its effects was created by The United States Department of Health and Human Services (HHS) (4). According to this 2015 government evaluation, 85 percent of Indiana consumers who signed up for health care in 2015 had the option of receiving it for \$100 or less after tax credits. Possibly due to this low price, since the ACA took effect, 16.4 million uninsured Americans have gained insurance, representing 30 percent of the pre-ACA uninsured population in

the country. This is the largest reduction of uninsured patients in 40 years, proving Americans are taking advantage of insurance availability (4).

Previous Studies

Previous research described three important topics: insurance, mammography utilization, and breast cancer survival. However, no single study has linked all three, which will be the goal of this paper. Mammography and survival were linked by the USPSTF (5). After extensive research, this body decided to require all insurance companies to cover biennial mammograms for all patients between the ages of 40 and 75. After 75, it was concluded there is not enough evidence to form an assessment, due to the high rate of comorbidities in this age range, which skews the data. This research suggests that survival rates are greatly affected by mammography utilization with sufficient evidence.

Insurance has also been shown to have a connection to mammography utilization. Populations with private insurance have much higher utilization rates than those on Medicaid or without insurance altogether (2). A study from the journal *Medical Care* found that uninsured women reported the lowest mammography use (38.3 percent), even relative to women in lower income brackets. Thus, the data suggests that lack of insurance is a stronger deterrent for receiving mammograms than income. In almost every instance, Medicaid patient trends were very similar to those of uninsured patients. With the ACA, a decline in the number of Americans without insurance or relying solely on public insurance has occurred (4), which would imply that a corresponding increase in mammography volumes will be seen as well, potentially leading to lower national death rates due to breast cancer. Here, the connection between insurance and mammography utilization is clear.

A strong link has also been demonstrated to exist between insurance and breast cancer survival by two New Jersey studies, published in the *New England Journal of Medicine and Cancer Medicine* respectively (6,7). They reported similar findings, namely that patients with Medicaid or no insurance had 1.5 times the chance of dying from breast cancer as the privately insured. More importantly, they found that Medicaid insurance conferred no improvement on chances of survival. Thus, private insurance seemed to be the best means of increasing survival rates. The ACA responded to these facts by opening private insurance to thousands of Americans who could not afford it previously.

Recent Developments

Recently, several influential health insurance companies have threatened to pull out of the ACA, due to large financial losses (8). These companies complain that most of the new individuals signing up for health insurance are those already in need of using it, and when they no longer need it, they stop paying premiums. Thus, insurance companies are not gaining enough revenue to pay for all the medical expenses they are covering. Should they end their support, universal coverage of mammograms will have limited impact on its target populations, as insurance will no longer be offered at prices people can afford. Therefore, revision to the existing law may be necessary to guarantee mammography coverage through low-cost insurance.

Gap in the Field

Clearly, there is a link between insurance, mammography, and breast cancer survival (2,5,6,7). President Obama attempted to address this linkage with the ACA (3). However, despite successes in increasing insurance prevalence among target populations (4), it is proving more difficult than expected (8), leading many to question its effectiveness. On the basis of four essential criteria: private insurance ownership, mammography utilization, average stage of breast cancer development upon discovery, and breast cancer survival, this paper will assess the ACA's impact, providing novel insight on the law's effectiveness and supporting arguments to continue, revise, or terminate the program.

Participants and Methods

This study was comparative, looking at data before and after the passage of the ACA, and observational, since there was no way to control patient actions and treatment. No randomization was involved in patient choice of insurance, breast cancer screenings, or treatment, which showed the effects of the ACA without interference from the researcher. To demonstrate the effectiveness of the ACA, mammography volumes, average stage of discovery, insurance mix (the percentage of patients using each different types of insurance), and five-year survival rates were examined over time. Significantly, the insurance mix data was originally broken down into smaller categories, such as Medicare and Medicaid.

This study analyzed data from the Indianapolis St. Vincent Breast Center registry and was completed in January 2016. It included female patients between the ages of 40 and 75, because this is the at-risk population benefitting from the mammography section of the ACA. The only exclusion criterion was death due to comorbidities. Breast center patients with these inclusion criteria were used as a convenience-based sample of the target population. Thus, the data can be used to suggest a hypothesis, which can be tested further with other population samples, but not to prove correlation. All data collected for this research was cleared with approval from the Institutional Review Board of with written consent from the Director of the Breast Center.

Results

About a quarter of patients used public insurance of some sort in 2011 (Figure 1a). About three quarters of patients used private insurance and a very small percentage were uninsured, either paying the full bill themselves, or receiving charity care. By 2015 the number of patients using public insurance grew significantly, causing a large decrease in those using private insurance (Figure 1b). Again, a small percentage was uninsured.

Over time, mammography volumes at the Breast Center have increased considerably from 6887 patients in fiscal year 2004 to 18436 patients in fiscal year 2013 (Figure 2). The steepest increase was seen from 2010 to 2011, immediately after the ACA was signed into law.

Average stage of breast cancer discovery fluctuated somewhat erratically during the measured time period, which ended around where it started at about 1.2 (Figure 3). Of the four years following the implementation of the ACA, three were characterized by decreases.

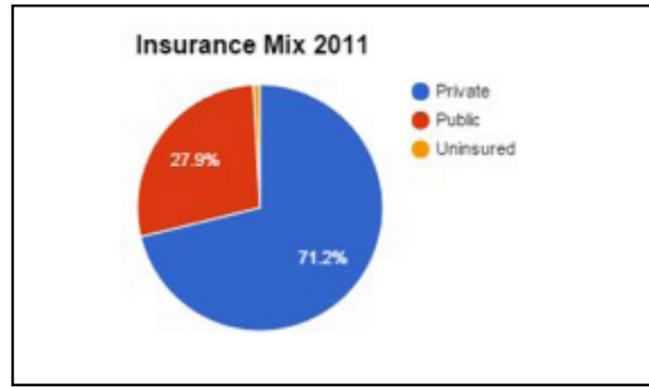


Figure 1a. Percentage of women using each type of insurance in 2011.

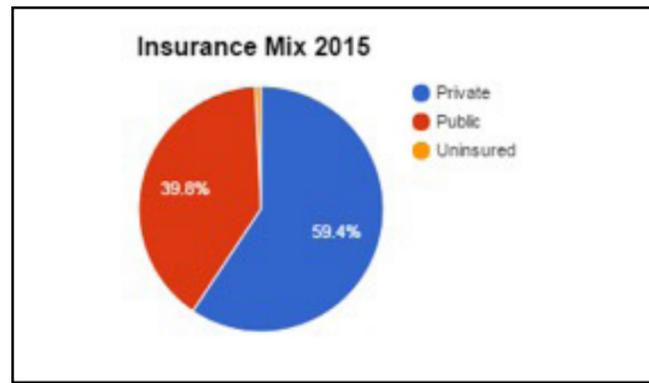


Figure 1b. Percentage of women using each type of insurance in 2015.

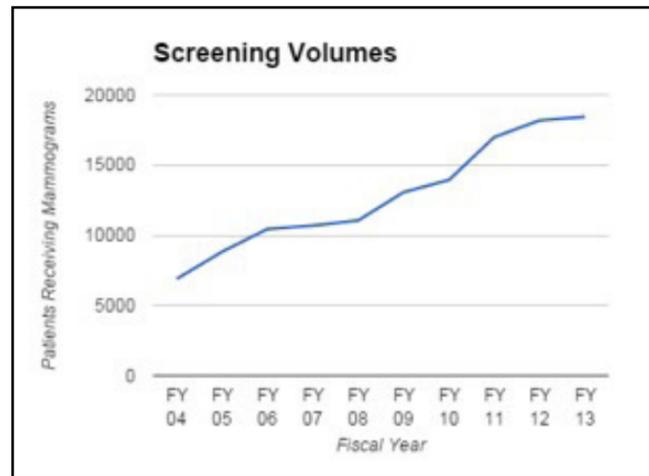


Figure 2. Number of women who sought mammograms 2004-2013.

Survival rates were measured in two time periods as well, 2005-2009 and 2010-2014. Those time periods started out with the same survival rates one year after diagnosis (Figure 4). By two years, the rates had diverged, with the earlier time period showing a higher survival rate. At five years, the later time period had the highest survival.

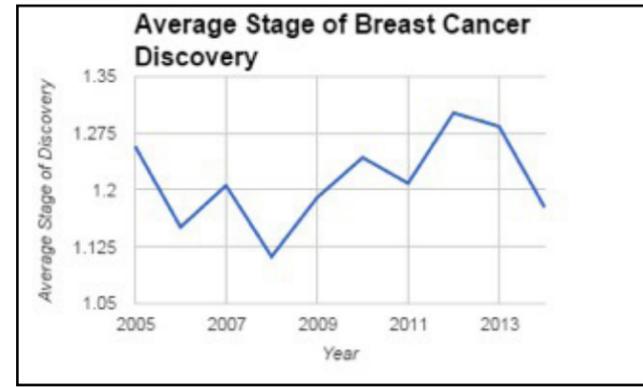


Figure 3. Average stage of breast cancer development upon discovery from 2005-2014.

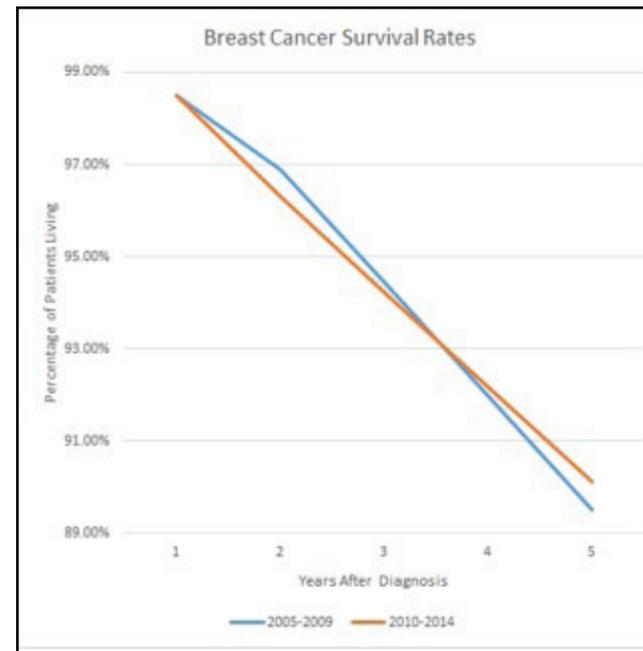


Figure 4. Percentage of breast cancer patients living after diagnosis.

Insurance Mix

Patients did not take advantage of the increased availability of private insurance, and thus, aggregate benefits for cancer patients cannot be attributed to the increased availability of private insurance in the last six years, according to these data. The population using private insurance decreased from 2011 to 2015 (Figure 1). The goal was to make private insurance available to a much wider demographic, instead of reserving it for those who could afford to pay. This plan was not completely successful for two reasons. First, with the aging of America's population, more citizens rely on Medicare, a public insurance option, negating increases in private insurance. As mentioned in the study design section, Medicare patients were grouped into public insurance for the purposes of this paper. Second, the public uses these newly offered, cheap, private insurance plans by selectively dropping them when they are no longer needed (8). These findings conflict with those of the HHS (4), which

is likely because of the area of study. In retrospect, data more sensitive to Medicaid might have excluded Medicare patients and originated from a breast center in a less affluent area.

Mammography Volumes

According to the data, universally free screening mammography was utilized, as mammography volumes increased significantly over the measured time period (Figure 2). Importantly, the steepest increase in usage occurred immediately following the implementation of preventative service coverage in 2010. The ACA directly made all screening mammographies free to every patient, without copay or deductible. This novel coverage caused a significant increase in utilization. This is in agreement with previous studies that found owning private insurance to be one of the strongest indicators of receiving mammograms (2). A limitation of this study is that it was performed at a single breast center, due to time and funding restrictions, so the data reflect local, not national, trends. Additionally, a portion of the increase in mammography volume was likely due to business growth, possibly due to newly recruited specialists to the center. Also, it is clear from the graph that volumes were already increasing before the ACA. Furthermore, the study was performed just a few years after the passage of the law and, thus, it had not had time to take full effect.

Average Stage of Discovery

Of the four years observed after ACA implementation, three were characterized by decreases in average stage. It may be postulated that the increase in mammography volumes was the cause. With more women taking advantage of free mammograms on a regular basis, average stage of discovery fell, because mammograms, when utilized effectively, detect breast cancer earlier. Random fluctuation can account for the one year with an increase, particularly because it occurred so soon after implementation. This period was part of an adjustment phase, possibly because women who had previously foregone mammograms were then discovering their tumors under the new plan. These findings agree with Ayanian et al., who found that privately insured patients who were better able to take advantage of screenings were diagnosed with distant stage cancer roughly half as often as those without private insurance (6). Again, this study was limited by time and location constraints, as explained earlier. If average stage of discovery follows this pattern nationwide in the coming years, it can be more concretely tied to the ACA.

Survival Rates

Some progress in five-year survival was observed, as the 2010-2014 period has slightly higher rates, which over time, could diverge even further from the pre-ACA baseline. Two-year survival was admittedly higher from 2005-2009, but five-year survival is a much better indicator, as cancer can often recur a few years after initial treatment. Thus, two-year survival is skewed, showing instead which time period had more cancer relapses after a few years. These findings support those of previous studies that found correlations linking mammography and insurance to survival (5,6,7). However, as noted earlier, the ACA's effects will likely be long-term, thus requiring more time

to become significant.

Conclusion

Using these results, it is clear the ACA was, to a degree, successful in exploiting the triple relationship of insurance, mammography, and survival, when judged by these four criteria. Yet the ACA is not ideal in its current form. Without action, it will either be lost completely or left only partially effective, resulting in avoidable loss of life. Further research is required to determine an exact path for revision, but tentative recommendations can be made from this information. Since the increase in mammography volumes is not fully translated to survival rates, amendments to the law could require insurance companies to help patients finance further treatment after screenings return positive, when financial situations warrant it. The government could also attempt to educate the public on mammograms. As reiterated multiple times, the data presented here are promising, but in most cases, not statistically significant. This academic paper has merely demonstrated that the law was a step in the right direction, as it increased mammogram volumes, leading to a relatively lower average stage of discovery and improved five-year survival rates.

References

1. Breastcancer.org. U.S. Breast Cancer Statistics. 2015. Available at: http://www.breastcancer.org/symptoms/understand_bc/statistics. Accessed December 10, 2015.
2. Sabatino SA, Coates RJ, Uhler RJ, Breen N, Tangka F, Shaw KM. Disparities in Mammography Use among US Women Aged 40-64 Years, by Race, Ethnicity, Income, and Health Insurance Status, 1993 and 2005. *Med. Care.* 2008;46(7):692-700. doi:10.1097/mlr.0b013e31817893b1.
3. Office of the Legislative Counsel. The Patient Protections and Affordable Care Act. Washington DC: Government Publishing Office; 2010:13.
4. HHS.gov. 5 Years Later: How the ACA is Working for Indiana. 2013. Available at: <http://www.hhs.gov/healthcare/facts-and-features/state-by-state/how-aca-is-working-for-indiana/index.html>. Accessed November 25, 2015.
5. Screening for Breast Cancer: U.S. Preventive Services Task Force Recommendation Statement. *Ann. Intern. Med.* 2009;151(10):716. doi:10.7326/0003-4819-151-10-200911170-00008.
6. Ayanian J, Kohler B, Abe T, Epstein A. The Relation between Health Insurance Coverage and Clinical Outcomes among Women with Breast Cancer. *New Engl. J. of Med.* 1993;329(5):326-331. doi:10.1056/nejm199307293290507.
7. Niu X, Roche L, Pawlish K, Henry K. Cancer Survival Disparities by Health Insurance Status. *Cancer Med.* 2013;2(3):403-411. doi:10.1002/cam4.84.
8. Mathews A, Armour S. Biggest Insurer Threatens to Abandon Health Law. *The Wall Street Journal.* 2015.

About the Author

Ryan Middleton is a freshman biology major from Carmel, Indiana. He is currently involved in Kathleen Eberhard's psychology language lab here at Notre Dame and intends to continue in research in the coming years. After graduation, he hopes to enter medical school.

Catchability of largemouth bass (*Micropterus salmoides*) on coarse woody habitat in a Northern USA temperate lake

Elizabeth Wildenhain¹

Advisor: Stuart Jones¹

¹University of Notre Dame, Department of Biological Sciences

Abstract

Coarse woody habitat (CWH), composed of dead treefall, has declined in lakes with shoreline development. As a result, some areas began to establish CWH restoration programs, but the effects of reintroducing CWH are not fully understood. As many of these lakes are used for recreational fishing, the effect on fish catchability is of particular interest. Toward this end, we measured the catchability of largemouth bass (Micropterus salmoides) by angling at coarse woody and exposed sites on Long Lake in Gogebic County, Wisconsin. Catchability was estimated from tagged bass recapture frequency at each site. A multiway repeated-measures ANOVA indicated a significant increase in catchability at CWH sites. We also examined the effect of time of day on catchability and found a significantly higher catchability in the evening compared to the morning. An increase in catchability at CWH sites has both drawbacks and benefits: CWH restoration could lead to overfishing but could also be used as a replacement for stocking to keep catch rates high. Although further studies are necessary to determine the cause of these increases in catchability, our results could help CWH restoration projects develop appropriate procedures and countermeasures to ensure the benefits of CWH reintroduction are achieved.

Introduction

Coarse woody habitat (CWH) “reefs”—accumulations of dead treefall—are a common feature of undisturbed lakes in forested regions. However, the abundance of CWH reefs have declined in developed areas due to the removal of trees from and around lakes (1,2). Loss of CWH can decrease littoral diversity, disrupt lake predator-prey interactions, and alter fish behavior (1,3). Recognition that a lack of CWH can negatively affect these ecological characteristics has led to management attempts in some developed areas to restore CWH by intentional introduction of wood to the littoral zone (1). The success of these projects, however, has been ambiguous, and the effects of increased CWH on other factors are often not fully understood or considered in the development of restoration plans (1). One such unexamined factor is the effect of CWH on fish catchability.

Catchability, a measure of the ease of capture of a particular fish population, can determine population declines

for some species. For example, aggregation of northern cod (*Gadus morhua*) around habitat structure can lead to increased catchability independent of total population density (4). Catchability is defined as the fraction of fish stock collected per unit effort (equation 1),

$$q = \frac{C/N}{E} \quad (1)$$

where C/N is an individual capture probability and E is total effort. The catchability of a species in a particular lake can be estimated using a tagged fish population and equation 2 where R_i is the total number of recaptures, A is the surface area of the lake, $M_{a,i}$ is the total number of tagged individuals, and E_i is effort in hours (5). Catchability varies in response to factors

$$q_i = \frac{R_i * A}{M_{a,i} * E_i} \quad (2)$$

such as species, season, lake, and fish behavior (4,5).

Restoration of CWH in developed areas could induce aggregation behavior in fish and increase their catchability in the restored lakes. In the Pacific Northwest, for example, lakes with shoreline development—and thus lower CWH—exhibit less fish aggregation, suggesting that restoration of CWH may in contrast lead to higher fish aggregation and catchability (6). Further, the aggregation of northern cod (*Gadus morhua*) around habitat structure leads to increased catchability independent of total population density and is the hypothesized cause of the collapse of the cod fishery in 1992 (4,7). Thus, it is possible that restoring CWH could lead to overfishing in these lakes if countermeasures are not considered. Therefore, directly characterizing the relationship between CWH and fish catchability is of applied ecological importance.

In this study, we examined the effect of shoreline CWH on fish catchability by comparing catchability of largemouth bass (*Micropterus salmoides*) on CWH reefs to that of exposed sites lacking CWH structure. Largemouth bass is a primarily littoral species whose behavior is influenced by CWH abundance: higher CWH causes bass to act more as sit-and-wait predators and to decrease their home range, in contrast to exposed areas, where they actively seek prey and have larger home ranges (8,9). Based on this and the increase in catchability associated with aggregation around habitat structure, we hypothesized that bass catchability would increase on CWH reefs. In this study, we also assessed catchability at different times of day. Understanding the unintended effects of management practices like CWH restoration can inform appropriate responses and regulations that should be put in place when such management is carried out, which could prevent undesirable ecological effects.

Materials and Methods

We conducted our study on Long Lake in the University of Notre Dame Environmental Resource Center (UNDERC) in Vilas County, Wisconsin and Gogebic County, Michigan. Long Lake is divided into two basins (East and West Long) with separate populations of largemouth bass (*Micropterus salmoides*), which have been previously marked with internal electronic tags. Each basin has a mixture of CWH and exposed habitat.

To identify coarse woody and exposed sites for sampling, we surveyed both basins for CWH and exposed habitat. On both East and West Long, we selected six sites of each habitat type (coarse woody and exposed) for a total of 12 sites per basin. CWH sites contained three or more logs of at least 150 cm in length and 5 cm in diameter, while exposed sites contained fewer than three such logs. We chose our exposed and CWH sites such that they differed markedly in CWH (i.e. in number of logs), were distributed around the entirety of the lake perimeter, and were not immediately adjacent to each other, in order to minimize recapture of the same individual at multiple sites. Each site contained 10 meters of shoreline, which we marked with flags on shoreline vegetation to facilitate locating the sites during data collection.

During mid-to-late June, we assessed the catchability of largemouth bass at each site on the two basins. We estimated catchability for four days per basin, starting at both 8:00 a.m. and 4:00 p.m. This was completed by angling from a boat for 10 minutes at each site and recording the number of tagged bass caught (R_i). The lure used was a rubber artificial worm (YUM Dinger®). We identified captured individuals with an electronic tag reader, held them until sampling at the site was completed, and then released them at the same site. For both morning and afternoon samplings, we randomized the order in which we visited the sites.

For each measure of bass recapture, we estimated catchability using equation (2) where R_i is the total number of tagged bass caught at the site, A is the surface area of the entire basin (East or West Long), $M_{a,i}$ is the total number of tagged bass in the basin, and E_i is effort in hours. To control for any potential effects of time of day on bass catchability, we performed a multiway repeated-measures ANOVA on the mean catchability values for each site, treating habitat (CWH or exposed) and time of day (morning or evening) as factors, and basin (East or West) as a block. Because bass are primarily littoral, we also calculated an adjusted catchability using shoreline perimeter in place of lake area and repeated the statistical analysis. To compare catchability on coarse woody sites at two population sizes, we calculated catchability using equation 2 without the area term. We then performed a randomized-block repeated-measures ANOVA on CWH site catchabilities with basin (East or West) as a factor and time of day (morning or evening) as a block. All statistical tests were performed in R (R Core Team 2013).

Results

A multiway repeated-measures ANOVA on the catchability estimates using lake area indicated that catchability was significantly higher at CWH than exposed sites (mean ± SE; coarse, 0.0465 ± 0.0048; exposed, 0.0232 ± 0.0048; $F_{1,21} = 9.962$, $p < 0.005$; Figure 1). A multiway repeated-measures ANOVA on the catchability estimates using shoreline perimeter likewise showed a significant increase in catchability at coarse woody sites (mean ± SE; coarse, 0.0121 ± 0.0013; exposed, 0.0060 ± 0.0013; $F_{1,21} = 8.981$, $p < 0.01$; Figure 2).

The multiway repeated-measures ANOVA using catchability calculated from lake area also indicated significantly higher catchability in the morning compared to the evening (mean ± SE; morning, 0.0236 ± 0.0056; evening, 0.0461 ± 0.0053; $F_{1,22} = 10.178$, $p < 0.005$; fig. 3). Similarly, the multiway repeated-measures ANOVA on catchability calculated from shoreline perimeter revealed a significant increase in catchability in the evening (mean ± SE; morning, 0.0062 ± 0.0016; evening, 0.0119 ± 0.0015; $F_{1,22} = 8.985$, $p < 0.01$; Figure 4).

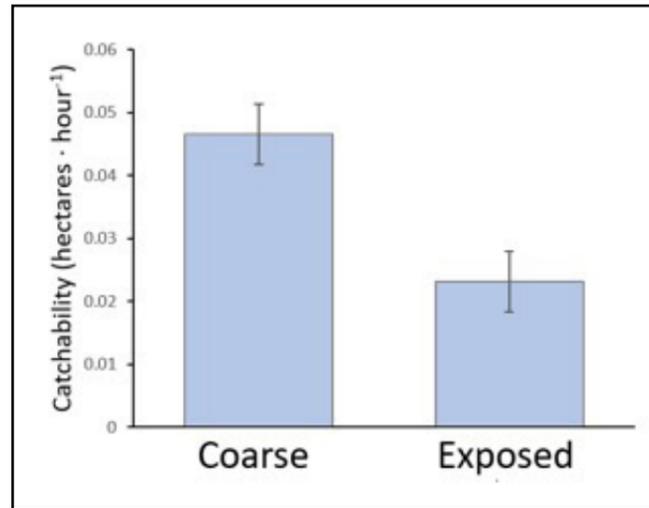


Figure 1. Comparison of bass catchability calculated with lake area at coarse woody and exposed sites. Catchability was calculated from tagged bass recapture frequency and lake area (equation 2) at coarse woody and exposed sites in both West and East Long. A multiway repeated-measures ANOVA with habitat and time of day as factors and basin as a block indicated that catchability was significantly higher at CWH than exposed sites ($F_{1,21} = 9.962$, $p < 0.005$).

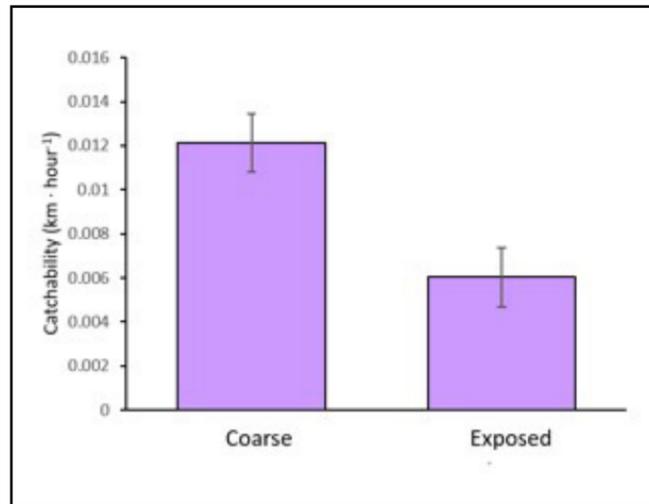


Figure 2. Comparison of bass catchability calculated with shoreline perimeter at coarse woody and exposed sites. Catchability was calculated from tagged bass recapture frequency and lake perimeter at coarse woody and exposed sites in both West and East Long. A multiway repeated-measures ANOVA with habitat and time of day as factors and basin as a block indicated that catchability was significantly higher at CWH than exposed sites ($F_{1,21} = 8.981$, $p < 0.01$).

$F_{1,22} = 10.178$, $p < 0.005$; fig. 3). Similarly, the multiway repeated-measures ANOVA on catchability calculated from shoreline perimeter revealed a significant increase in catchability in the evening (mean ± SE; morning, 0.0062 ± 0.0016; evening, 0.0119 ± 0.0015; $F_{1,22} = 8.985$, $p < 0.01$; Figure 4).

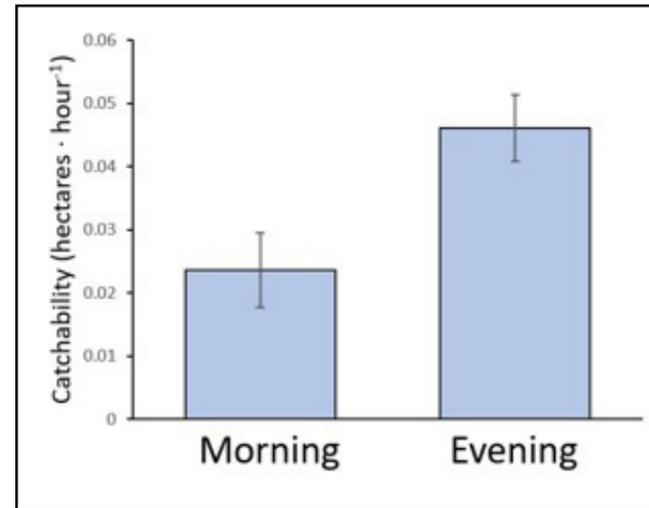


Figure 3. Comparison of bass catchability calculated with lake area in the morning and evening. Catchability was calculated from tagged bass recapture frequency and lake area (equation 2) in the morning and evening at all sites in both West and East Long. A multiway repeated-measures ANOVA with habitat and time of day as factors and basin as a block indicated that catchability was significantly higher in the evening than in the morning ($F_{1,22} = 10.178$, $p < 0.005$).

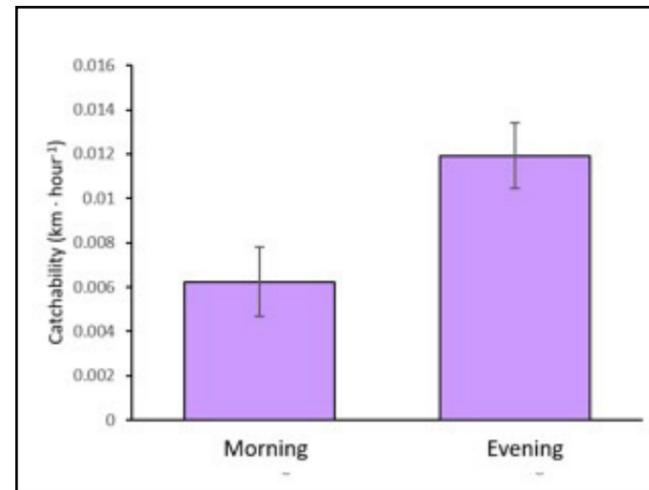


Figure 4. Comparison of bass catchability calculated with shoreline perimeter in the morning and evening. Catchability was calculated from tagged bass recapture frequency and lake perimeter in the morning and evening at all sites in both West and East Long. A multiway repeated-measures ANOVA with habitat and time of day as factors and basin as a block indicated that catchability was significantly higher in the evening than in the morning ($F_{1,22} = 8.985$, $p < 0.01$).

A randomized-block repeated-measures ANOVA on catchability calculated from two population sizes indicated no significant difference between East Long and West Long at coarse woody sites (mean ± SE; West Long, 0.0106 ± 0.0020; East Long, 0.0109 ± 0.0020; $F_{1,10} = 0.013$, $p >> 0.05$; Figure 5).

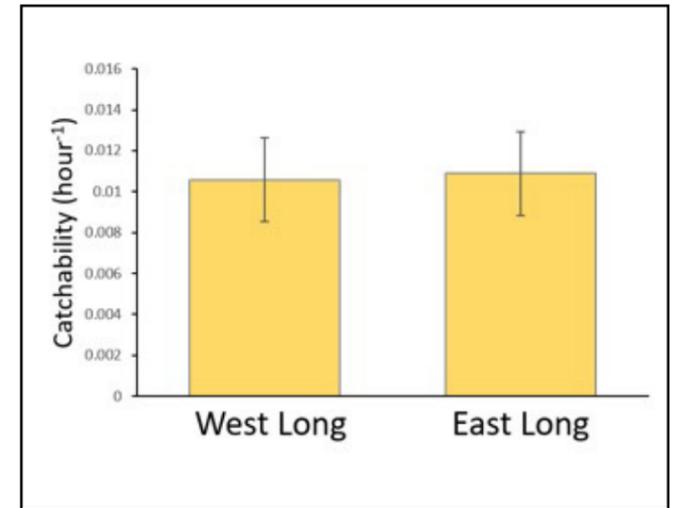


Figure 5. Comparison of bass catchability in the two basins at coarse woody sites. To compare catchabilities across population densities at the coarse woody sites, catchability for each basin was calculated from equation 2 without the area term. A randomized-block repeated-measures ANOVA with basin as a factor and time of day as a block indicated that there was no significant difference in catchability at coarse woody sites across basins (mean ± SE; West Long, 0.0106 ± 0.0020; East Long, 0.0109 ± 0.0020; $F_{1,10} = 0.013$, $p << 0.05$).

Discussion

Our results indicate a significant increase in bass catchability at sites with CWH. The role of CWH as habitat structure might explain this increase, as CWH can induce fish aggregation (10). Furthermore, previous studies indicated that largemouth bass tend to decrease both their home ranges and active searching for prey (9). Therefore, it is likely that CWH induces bass aggregation, which couples with a stationary behavior and sit-and-wait predation, leading to higher catchability at CWH sites. We did not directly measure fish aggregation levels, but our results suggest future studies should measure the relationship between CWH and largemouth bass aggregation or between largemouth bass aggregation and catchability.

Increased largemouth bass catchability on CWH has implications for lake fisheries management, especially if a similar catchability increase occurs with other fish species. Restoration initiatives, such as the “Fish Sticks” projects by Wisconsin Department of Natural Resources, must account for increased catchability as CWH is added to previously depleted lakes (11). Such projects ought to take appropriate countermeasures to avoid overfishing, such as reducing bag limits on fish taken from lakes with restored CWH or encouraging catch-and-release, so that the potential benefits of CWH are realized.

In addition, this increase in catchability could be useful in lakes that are stocked to keep catch rates high. Stocking fish is an expensive endeavor; for example, a complete stocking project of largemouth bass in the Harris Chain of Lakes, FL cost almost \$500,000 between 2004 and 2013 (12). In contrast, reintroduction of CWH is relatively inexpensive and requires little maintenance (13). If CWH restoration can significantly increase the catchability of bass, and potentially other species,

using CWH could improve the economy of maintaining high catch rates in frequently fished lakes. Since CWH has ecological additional benefits such as providing refuge for young of the year fish, important for natural recruitment and stock rebuilding—CWH restoration may reduce reliance on stocking and could better preserve recruitment and fish stocks in heavily fished lakes (14,15,16). These benefits would only manifest if fishing is catch-and-release on the restored lake, as harvesting without stocking would deplete the fish population. Angler satisfaction is often determined by catch rate and fish size, both of which can be maximized in a catch-and-release system (17). Furthermore, a 2011 survey of northern Wisconsin sport fish catch-and-release rates found that high proportions of fish caught are released by anglers, with nearly all largemouth and smallmouth bass released after capture (18). Thus, increasing catch rates by CWH reintroduction deserves consideration as a replacement for stocking despite its restriction to catch-and-release programs.

One concern of increased catchability at CWH sites is high catch rates even at low population densities, a phenomenon known as “hyperstability” (19). Hyperstability can mask population collapse in fisheries by suggesting a constant population size while the fish population in fact declines, which has been the case in barred sand bass, kelp bass, and rainbow trout fisheries (20,21). In our study, the population sizes of tagged largemouth bass differed between East and West Long (356 and 461 tagged individuals, respectively), but we found no significant difference in catchability at coarse woody sites between basins when calculating catchability from population size. This result agrees with the hypothesis that increased catchability with high CWH abundance poses a threat of hyperstability.

Bass population densities were relatively high in both basins, however, and other factors (such as levels of dissolved organic carbon) varied between the basins. To fully examine the risk of hyperstability at sites with increased CWH, a study of catchability at varying bass densities could be completed by temporarily removing a portion of the bass population in one basin, in order to artificially decrease the population density in one basin. If high catch rates are maintained in CWH areas despite a decrease in fish density, hyperstability in response to higher CWH levels is a concern that should be considered in fishery management. This would also reinforce our conclusions about the drawbacks and benefits of CWH restoration: High catch rates at low densities could lead to overfishing or could be used as a management technique in place of fish stocking, if proper catch regulations are adopted and followed.

Our results also indicate an increase in bass catchability in the evening when compared to the morning. As water temperature alters bass activity levels, this difference in catchability could be related to temperature or other weather variation throughout the day (22). A future study examining the relationship between various weather conditions (especially temperature) and bass catchability could help determine the cause behind increased catchability later in the day. Comparing CWH and exposed sites in such a study would be of interest as well. Perhaps CWH increases catchability more at colder water temperatures, as bass tend to be less active in colder conditions and may therefore aggregate in a more stationary manner around habitat structure.

The results of such studies, combined with our conclusion that CWH increases bass catchability, could further inform CWH restoration projects to develop appropriate fishing regulations, thus helping to ensure that the benefits of CWH reintroduction are achieved.

In conclusion, our study revealed that the catchability of largemouth bass is significantly higher in the presence of CWH and in the evening. Further studies would aid in uncovering more precise reasons for these increases. In the meantime, knowledge of these trends can inform present fishery management programs involving CWH restoration.

Acknowledgements

Special thanks to Jake Ziegler for continued guidance throughout the study. Thanks also to the class teaching assistants, Catherine McQuestion and Kristin Bahleda, for constructive criticism and advice. I would like to give special thanks to the Bernard J. Hank Family Endowment for its generous support. I would also like to extend my gratitude to the entire UNDERC class for assistance and support throughout the project, especially Rodrigo Rivero, for accompanying me frequently in the field. Thank you also to my family for helping to make this summer research possible.

References

1. Czarnecka, M. Coarse woody debris in temperate littoral zones: implications for biodiversity, food webs, and lake management. *Hydrobiologia*. 767(1):13-25 (2016).
2. Christensen, D. L., B. R. Herwig, D. E. Schindler, and S. R. Carpenter. Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. *Ecol. Appl.* 6(4):1143-1149 (1996).
3. DeBoom, C. S., and D. H. Wahl. Effects of coarse woody habitat complexity on predator-prey interactions of four freshwater fish species. *Trans. Am. Fish. Soc.* 142: 1602-1614 (2013).
4. Rose, G. A., and D. W. Kulka. Hyperaggregation of fish and fisheries: how catch per unit effort increased as the northern cod (*Gadus morhua*) declined. *Can. J. Fish. Aquat. Sci.* 56(S1):118127 (1999).
5. Hangsleben, M. A., M. S. Allen, and D. C. Gwinn. Evaluation of electrofishing catch per unit effort for indexing fish abundance in Florida lakes. *Trans. Am. Fish. Soc.* 142(1):247256 (2013).
6. Scheuerell M. D., and D. E. Schindler. Changes in the spatial distribution of fishes in lakes along a residential development gradient. *Ecosystems*. 7(1):98106 (2004).
7. Hutchings, J. A. Spatial and temporal variation in the density of northern cod and a review of hypotheses for the stock's collapse. *Can. J. Fish. Aquat. Sci.* 53(5):943962 (1996).
8. Essington, T. E. and J. F. Kitchell. New perspectives in the analysis of fish distributions: A case study on the spatial distribution of largemouth bass (*Micropterus salmoides*). *Can. J. Fish. Aquat. Sci.* 56:52-60 (1999).
9. Ahrenstorff, T. D., Sass G.G., M. R. Helmus. The influence of littoral zone coarse woody habitat on home range size, spatial distribution, and feeding ecology of largemouth bass (*Micropterus salmoides*). *Hydrobiologia*. 623:223 (2008).

10. Garcia-Charton, J. and Pérez-Ruzafa, Á. Spatial pattern and the habitat structure of a Mediterranean rocky reef fish local assemblage. *Mar. Biol.* 138:917 (2001).

11. Wisconsin Department of Natural Resources. Fish sticks: Improving lake habitat. Available: <http://dnr.wi.gov/topic/fishing/outreach/fishsticks.html>. (July 15, 2016).

12. Canfield, D. E., D. J. Pecora, K. W. Larson, J. Stephens, and M. V. Hoyer. Stocking wild adult Florida largemouth bass (*Micropterus salmoides floridanus*): An additional fish management tool. *Lakes & Reservoirs: Research & Management*. 18(3):239-245 (2013).

13. Lester, R. E., and A. J. Boulton. Rehabilitating Agricultural Streams in Australia with Wood: A Review. *Environ. Manage.* 42:310 (2008).

14. Schindler, D. E., S. I. Geib, M. R. Williams. Patterns of Fish Growth along a Residential Development Gradient in North Temperate Lakes. *Ecosystems*. 3:229-237 (2000).

15. Walters C. and J. F. Kitchell. Cultivation/depensation effects on juvenile survival and recruitment: implications for the theory of fishing. *Can. J. Fish. Aquat. Sci.* 58:39-50 (2001).

16. Sass, G. G., C. M. Gille, J. T. Hinke, and J. F. Kitchell. Whole-lake influences of littoral structural complexity and prey body morphology on fish predator-prey interactions. *Ecol. Freshw. Fish.* 15:301-308 (2006).

17. Beardmore, R., L. M. Hunt, W. Haider, M. Dorow, and R. Arlinghaus. Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and the anglers. *Can. J. Fish. Aquat. Sci.* 72:1-14 (2014).

18. Gaeta, J. W., A. W. Latzka, B. Provencher, and S. R. Carpenter. Catch-and-Release Rates of Sport Fishes in Northern Wisconsin from an Angler Diary Survey. *N. Am. J. Fish. Manage.* 33(3):606-614 (2013).

19. Hilborn, R. and C. J. Walters. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman and Hall, New York (1992).

20. Erisman, B. E., L. G. Allen, J. T. Claisse, D. J. Pondella II, E. F. Miller, J. H. Murray. The illusion of plenty: hyperstability masks collapses in two recreational fisheries that target fish spawning aggregations. *Can. J. Fish. Aquat. Sci.* 68(1):1705-1716 (2011).

21. Ward, H. G. M., Askey, P. J., Post, J. R. A mechanistic understanding of hyperstability in catch per unit effort and density-dependent catchability in a multistock recreational fishery. *Can. J. Fish. Aquat. Sci.* 70(10):1542-1550 (2013).

22. Hasler, C. T. C. D. Suski, K. C. Hanson, S. J. Cooke, D. P. Philipp, and B. L. Tufts. Effect of water temperature on laboratory swimming performance and natural activity levels of adult largemouth bass. *Can. J. Zool.* 87(7):589-596 (2009).

About the Author

Liz Wildenhain is a junior at Notre Dame doubling majoring in physics and philosophy with a minor in the Glynn Family Honors Program. Although now pursuing physics, Liz has a respectable background in ecology, performing research at the University of Notre Dame Environmental Research Center, the Galapagos Islands (through a Notre Dame program), and on campus with the Jones Aquatic Ecology Lab. Liz now works on research in particle physics theory with Prof. Adam Martin. Whether through physics, philosophy, or some other field, Liz hopes to make discoveries that impact the foundations of scientific knowledge.

TALK SCIENCE

October 11, 2016



Prof. Margaret Dobrowolska
Department of Physics

Semiconductors: What Are They and Why Do We Need Them

Claire Kampman
Biological Sciences '17

Ibuprofen Regulation of Microtubule Dynamics in Cystic Fibrosis Epithelial Cells



November 21, 2016



Prof. Marie Donahue
Notre Dame Haiti Program Director

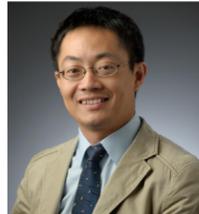
Unexpected Opportunities

Harrison Schurr
Physics in Medicine '17

Damage to DNA Induced by H₂O₂ Produced During Atmospheric Plasma Jet Irradiation



December 6, 2016



Dr. Siyuan Zhang
Department of Biological Sciences

Career Paths in the Bewildered Biomedical Field

Danielle Boley
Biochemistry '17

Metabolomic Analysis of the Development of Xenopus laevis Embryos



February 7, 2017



Prof. Jason McLachlan
Department of Biological Sciences

How to Improve Forecasts of Changing Climate

Brandon Roach
Physics '17

Simulating Production of the Heavy Elements



February 28, 2017



Prof. Jeffrey Diller
Department of Mathematics

Learning To Do Math: What Worked For Me

Jugyeong (Esther) Lee
Science-Business '18

Analyzing Effects on Aedes aegypti Fecundity and Blood Feeding Behavior



April 4, 2017



Prof. Matthew Ravosa
Department of Biological Sciences

Integrative Approaches to the Evolution, Development, and Function of the Mammalian Skull

Andrew Latham
Chemistry and ACMS '17

Computational Study of Pt Surface Reconstruction in the Presence of CO



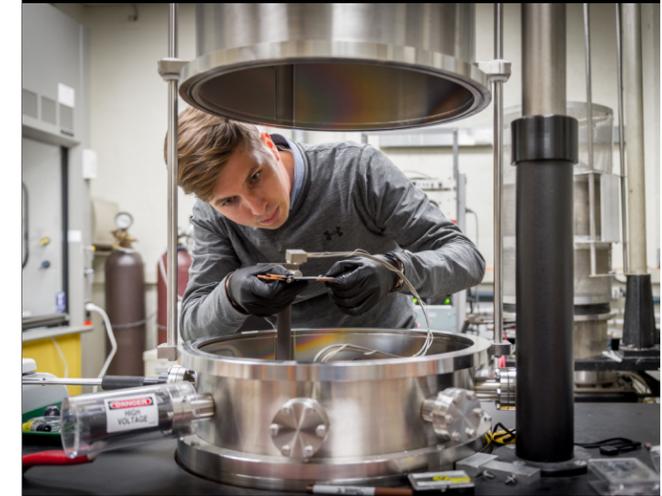
RESEARCH

Want to get involved in undergraduate research? For more information about undergraduate research opportunities at the University of Notre Dame, visit science.nd.edu/undergradresearch.



PUBLISH

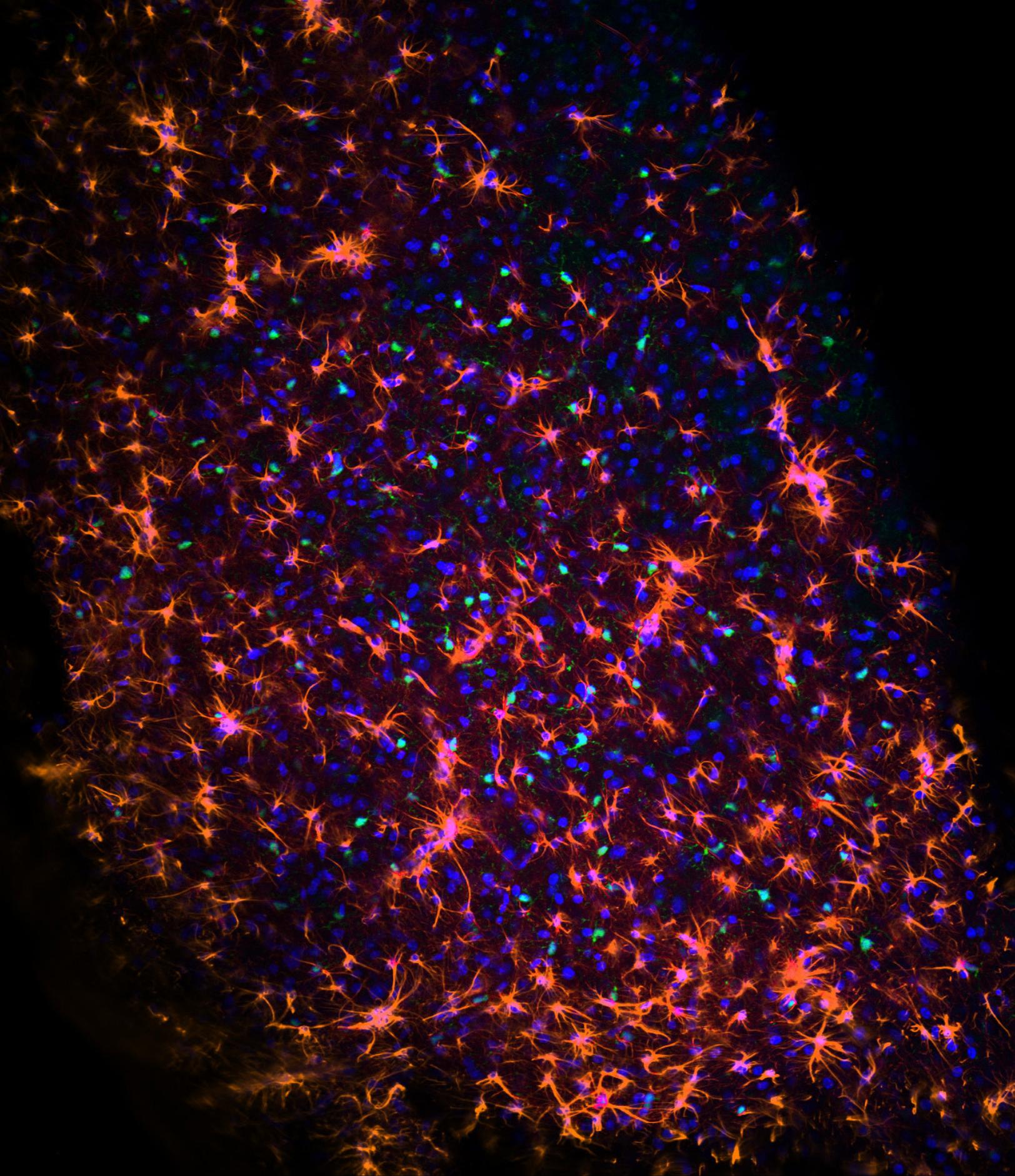
Interested in publishing your research in the next issue of *Scientia* or presenting at the next Talk Science seminar? Email the editors at scientia@nd.edu.



JOIN US

Want to help publish the next issue of *Scientia*? We are currently seeking reviewers, editors, news columnists, and graphic designers for the upcoming semester. Email scientia@nd.edu for details.





UNIVERSITY OF
NOTRE DAME

College of Science