






Feeding the Kidney Researcher Pipeline through R25-NIDDK Funded Summer Undergraduate Research Fellowships: A Student Perspective

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KIDNEY360 3: 546–549, 2022. doi: <https://doi.org/10.34067/KID.0001272021>

Introduction

In an effort to grow the field of kidney research, an educational “pipeline” has been developed to educate and engage students in kidney-related research early in their training and provide support throughout their careers. While some programs emphasize recruiting medical students or residents into nephrology, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) has established R25-funded summer programs to engage undergraduate students in nephrology, urology, and non-malignant hematology (KUH)-related research, referred to in this text as SURFs (Summer Undergraduate Research Fellowships). These SURF programs specifically support the development of research skills, and exposure to careers related to kidney, urologic, and hematologic diseases, diabetes, other endocrine and metabolic diseases, digestive diseases, nutritional disorders, and obesity, emphasizing states of health and disease (<https://grants.nih.gov/grants/guide/rfa-files/RFA-DK-13-005.html>). These programs, targeted for the un-differentiated undergraduate student, reach out at a critical time when students are exploring and clarifying career options and may play a vital role in forming future KUH-related researchers (1–3). Overall, the goal of the NIDDK SURF programs is to pique student interest in research related to the KUH-related initiatives by reinforcing their intent to pursue professional science degrees and by informing students of the many careers available to them in KUH-related fields (Figure 1).

As a multi-institutional initiative (Table 1), SURFs provide the opportunity for students to be engaged in kidney, hematologic, and urologic research under the mentorship of established researchers and clinicians at major research institutes throughout the country. A typical SURF experience consists of an 8- to 12-week experience, during which students hone lab skills,

learn the basics of renal physiology, and attend didactic lectures at their institution with several programs offering opportunities to observe KUH-related clinical activities. The summer culminates with students from across campuses presenting their work at a conference-style symposium, with a further subset of students selected to attend the American Society of Nephrology (ASN) Kidney Week meeting through the “ASN Kidney STARS” program. The following narratives describe our first-hand experience as three students who participated in R25 summer programs, and who have since continued to pursue careers related to kidney research.

Student Perspectives

Elena

What was your experience like and what are you doing now?

In my second year as a post-baccalaureate research fellow at the National Cancer Institute, I credit much of my research success to the skills I gained participating in SURF programs at the Mayo Clinic and Yale School of Medicine. During my time in these programs, I investigated how urinary extracellular vesicles can be used as markers for kidney stone disease, examined how inflammatory cell populations differ between patients with and without kidney stone disease, and applied whole exome sequencing to identify copy number variants that aligned with novel mutations in polycystic kidney disease and polycystic liver disease genes. My mentors in these programs provided multiple examples of the diversity and breadth of what research careers might look like and cemented my desire to pursue a career in research. These experiences provided me with opportunities to share my findings through abstract and manuscript submissions, and presentations in poster sessions.

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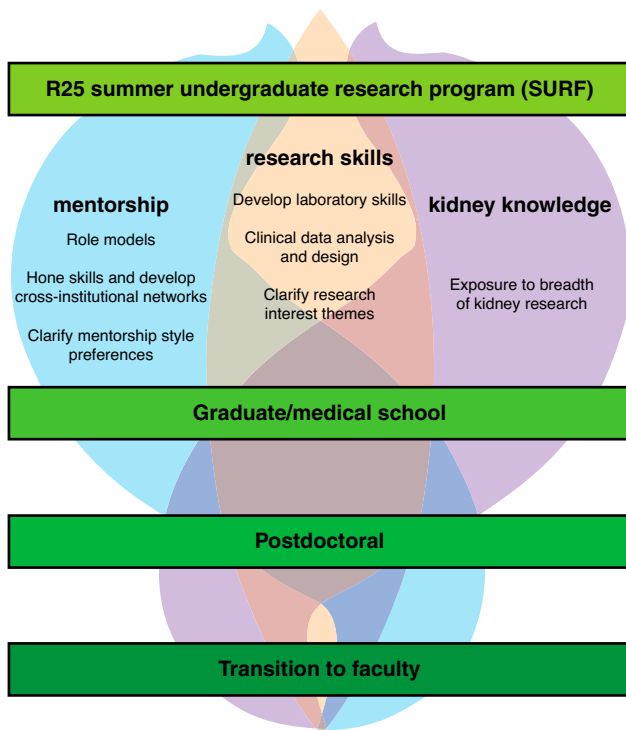


Figure 1. | R25 Summer Undergraduate Research Fellowship programs enhance the kidney research pipeline. Interest in kidney research can be initiated by SURFs in part by the three threads of mentorship, research skills, and kidney knowledge. These threads are further enhanced by later stages of education.

As a result of my training through these programs, I am now applying to MD-PhD programs where I hope to utilize my passion for research to address clinically relevant questions and improve treatments for patients.

What did you gain from your time in R25 programs?

Within these programs, I cultivated a tool-box of wet lab skills through different experimental protocols and informal courses in human physiology and biostatistics. I was also able to hone my critical thinking skills and begin to propose my own experiments and hypotheses. Through mentorship and collaboration, I was given a safety net to fail, which taught me valuable lessons about perseverance and open-mindedness with regard to scientific inquiry. Throughout these experiences, I became more and more interested in nephrology after seeing the direct potential of my research to improve treatments and, by extension, patients' lives. Attending ASN's Kidney Week conferences and presenting my research provided me with an opportunity to network and be exposed to the interdisciplinary nature of nephrology, interfacing genetics, immunology, artificial intelligence, and big data to solve problems. These programs have been defining experiences in driving me toward a career where I can apply research to improve clinical medicine. The connections I have made have given me a cohort of equally motivated peers and mentors who are passionate about using science to make change. I am incredibly thankful for these opportunities and know so

much of who I am as a scientist is due to my participation in these programs. I aim to be a physician-scientist and pursue basic science research for translation into clinical medicine, specifically nephrology.

Clayton

Where are you now?

I am a fifth year MD-PhD student at the University at Buffalo (UB). I am currently working toward my PhD studying the ion transporters and cellular basis of systemic acid-base balance. I plan to pursue research residency programs once I graduate, with the hope of continuing with kidney research while pursuing a clinical renal fellowship.

How did the experience influence the path to where you are now?

I participated in the Mayo Clinic SURF program (called "nuSURF") for two summers, during which I worked on developing a clinical assay for cystinuria, an inherited disease that manifests with cystine crystals and stones. My time at Mayo showed me what a career in research looked like. It was very exciting to be a part of a project from start to finish and the translational nature of the project allowed a better understanding of how basic research and clinical medicine coincide. The experience solidified my decision to pursue acceptance to an MD-PhD program, and furthermore, it led me to seek out kidney-focused labs when I was on the interview trail. That is specifically how I ended up working in my current lab, as it was one of the few at UB doing renal-related work. Now, as a graduate student, I have taken advantage of other programs supported by ASN, such as the Student and Residents (STARS) program during the Kidney Week conference. I have also been successful in obtaining fellowship funding for the remainder of my time at UB in the form of an F30 grant through the NIDDK. I never would have looked for these opportunities, let alone pursued a PhD focused on the kidney, if I had not been exposed to it through the SURF program at Mayo.

Sarah

Why did you apply to the SURF program?

As a chemical engineering and biology double major, I enjoyed learning about the separation of chemicals, and during a physiology class I was particularly interested in learning about the kidney. Given my interest in medicine, I chose to take physiology, but I acknowledge that many of my peers lacked this early exposure as physiology and anatomy courses are not required in all plans of study. I was interested in medicine and applied to MD-PhD-focused SURFs. The Yale School of Medicine kidney-focused SURF seemed like a place to explore the interest in the kidney further.

How did the summer experience change your current trajectory?

Beyond developing physical wet lab and experimental design skills, the SURF helped me explore and broaden my perspective on research. My undergraduate institution at the time did not have a medical school, which limited my exposure to academic medical research. Through the SURF program, I saw first-hand the daily life of physician-scientists, their role in academic medicine, and the types of

Table 1. Example R25 kidney Summer Undergraduate Research experiences (SURF)

University	Program Name	URL	R25-Funded Students per Year (Estimated Students to Date)	Year Established
Emory University School of Medicine	Summer Undergraduate Program in Emory Renal Research (SUPERR)	https://med.emory.edu/departments/medicine/divisions/renal-medicine/education/superr-program/index.html	12 (approximately 84 total)	2014
Harvard Medical School	The Harvard Summer Research Program in Kidney Medicine (HSRPKM)	https://hskp.bwh.harvard.edu/	14 (approximately 98 total)	2014
Mayo Clinic	Nephrology and Urology Summer Undergraduate Research Fellowship (nuSURF)	https://www.mayo.edu/research/centers-programs/obrien-urology-research-center/education/undergraduate-research	14 (approximately 98 total)	2014
University of Alabama-Birmingham	Kidney Undergraduate Research Experience (KURE)	https://www.uab.edu/medicine/nephrology/research/cardio-renal-physiology-and-medicine/kure	14 (approximately 28 total)	2019
University of Texas-San Antonio Health Sciences Center	San Antonio Program for Undergraduate Research in Renal Science (SPURRS)	https://www.uthscsa.edu/academics/biomedical-sciences/programs/summer	8 (approximately 16 total)	2019
University of Texas-Southwestern	Summer Undergraduate Research Institute for the Study of Kidney Disease (SURISKD)	https://www.utsouthwestern.edu/education/graduate-school/research-opportunities/suriskd/	15 (approximately 105 total)	2014
Vanderbilt School of Medicine	Aspirnaut™ – Undergraduate Discovery Science Experience in Renal Biology and Disease	https://medschool.vanderbilt.edu/vssa/aspirnaut-undergraduate-discovery-science-experience-in-renal-biology-and-disease/	10 (approximately 80 total)	2013
Yale School of Medicine	Yale Summer Undergraduate Medical Research (SUMR) (NIH-NIDDK/KUH)	https://medicine.yale.edu/intmed/nephrol/research/summerresearch/	10 (approximately 70 total)	2014

^aAdditional participating institutions include Loyola University, Boston Medical Center, Icahn School of Medicine, Stanford University, Texas A&M, University of Arizona, University of Pittsburgh, University of Virginia, and Wake Forest University.

questions they asked, leading me to pursue the MD-PhD pathway. Currently, I am a sixth-year student in the medical scientist training program in the Indiana University School of Medicine-Purdue University program. The exposure to different principal investigators (PIs) and diverse research topics in didactic sessions at the Yale SURF program helped me clarify my preferred research themes and mentor style preferences. During my summer at Yale, I was intrigued by imaging, mouse genetics, and developmental research, and realized I wanted to learn from the direct experimental mentorship of a PI. Because of these clarifying experiences, I selected a lab to develop these skills and an early-stage PI with a very engaged mentorship style. Although the lab was not kidney-focused, my PI gave me the flexibility to pursue a kidney-related project as long as it was hypothesis driven. Motivated by the SURF

experience and supported by subsequent nephrology connections made in part by ASN's kidney STARS program, I am applying techniques developed by the lab to the kidney. Additionally, as I look forward to developing the skills to be successful at the next research stage (fellow or post-doctoral fellow), it has been helpful to reflect back on different lab formats and attributes I will need to develop to be successful.

Discussion

R25 SURF programs provide students with a unique look into what a career in research, specifically kidney research, entails, as well as the varying professional degrees that enable these careers. This early exposure provides support to explore personal interests while

developing directly translatable skills that prepare students for further study. At the conclusion of the summer, the multi-institute symposium (KUH Summer Undergraduate Symposium) provides a glimpse into the myriad of different projects that fall under the category of KUH-related research. This symposium gives many students their first opportunity to present scientific work to a broad, national audience and allows for networking and exposure to different programs through which they may be able to pursue further training. This early exposure, at the undergraduate level, helps plant a seed for an interest in the kidney; even if a student does not intend to pursue research related to their individual project, they will be more motivated to seek additional opportunities within the context of kidney research in the future. Further improvement of the programs could include the establishment of an alumni reception at ASN Kidney Week to help make and strengthen connections with peer alumni at different stages of training and the creation of an NIH virtual platform providing access to alumni who participated in these KUH programs. This would facilitate the exchange of ideas, troubleshooting of experiments, and the opportunities for mentorship and career guidance. The success of these R25-funded programs in motivating pursuit of professional scientific degrees is becoming more evident as over 500 students have participated and have now had the opportunity to enroll in graduate programs or begin to establish KUH-oriented careers. Moving forward, continued dedication to tracking program alumni will be important for characterizing the link between participation in these R25-funded programs and entrance into the kidney researcher pipeline. In our individual cases, participation has had a profoundly positive impact on the trajectory of our academic careers, and we encourage continued support for these programs.

Disclosures

S. Ishibe has received research funding from NIH, honoraria from the University of Michigan and Walden Pharmaceuticals and is an Associate Editor of *Kidney360*. M. Romero has received research funding from MediBeacon and SonoVol, Inc. (SBIR/R43-DK126607), is an Associate Editor of *Kidney360*, is a scientific advisor or member of *Am J Physiol Renal Physiol*, Oxalosis Hyperoxaluria Foundation (OHF), NIDDK study sections, ad hoc. The remaining authors have nothing to disclose.

Funding

This work is supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health under Award Number F30DK126330 (to C.B.). These summer programs were supported by R25 mechanism grants, including R25-DK101405 (Mayo Clinic College of Medicine & Science) and R25-DK121566 (Yale School of Medicine).

Acknowledgments

The content of this article reflects the personal experience and views of the author and should not be considered medical advice or recommendations. The content does not reflect the views or opinions of the American Society of Nephrology (ASN) or *Kidney360*. Responsibility for the information and views expressed herein lies entirely with the author(s).

We thank *Kidney360* for the opportunity to contribute, the NIH/NIDDK-KUH for funding these summer research programs, and our respective programs and research mentors.

Author Contributions

S. Ishibe, M.F. Romero, E.M. Wilson conceptualized the study; C.T. Brady, S.N. Lipp, and E.M. Wilson were responsible for formal analysis; E.M. Wilson was responsible for data curation, project administration, resources, and validation, and wrote the original draft; S. Ishibe and M.F. Romero were responsible for funding acquisition; S. Ishibe, M.F. Romero, and E.M. Wilson provided supervision; C.T. Brady, S. Ishibe, S.N. Lipp, M.F. Romero, and E.M. Wilson reviewed and edited the manuscript.

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Received: February 25, 2021 **Accepted:** October 19, 2021

S.I. and M.F.R. contributed equally to this work.