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Planning for Research after COVID

Merrill Series on
The Research Mission of Public Universities

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Mabel L. Rice, Editor
Technical Editor: Cari Vukelich

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Introduction

Mabel Rice
The Fred and Virginia Merrill Distinguished Professor of Advanced Studies and Director, Merrill Advanced Studies Center, University of Kansas

The following papers each address an aspect of the subject of the twenty-fourth annual research policy retreat hosted by the Merrill Center: Planning for Research after COVID. We are pleased to continue this program that brings together University administrators and researcher-scientists for informal discussions that lead to the identification of pressing issues, understanding of different perspectives, and the creation of plans of action to enhance research productivity within our institutions. The COVID pandemic led to the cancellation of the Merrill Research Retreat in 2020. In 2021 the focus was on the impact of the COVID pandemic on our universities, with a concentration on the challenges for research in the wake of the pervasive effects of the pandemic.

Our keynote speaker for the event was Dr. Joseph Steinmetz, former Chancellor of the University of Arkansas. In his presentation, he describes the state of higher education prior to the pandemic, the challenges universities faced over the last two years, and predictions of the post-pandemic environment.

Benefactors Virginia and Fred Merrill make possible this series of retreats: The Research Mission of Public Universities. On behalf of the many participants over two decades, I express deep gratitude to the Merrills for their enlightened support. On behalf of the Merrill Advanced Studies Center, I extend my appreciation for the contribution of effort and time of the participants and to the authors of this collection of papers who found time in their busy schedules for the preparation of the materials that follow.

Eighteen administrators, faculty, and students from six institutions in Kansas, Arkansas, Missouri, Iowa, and Nebraska attended in 2021, which marked our twenty-fourth retreat. Though not all discussants' remarks are individually documented, their participation was an essential ingredient in the general discussions that ensued and the preparation of the final papers. The list of all conference attendees is at the end of the publication.

The inaugural event in this series of conferences, in 1997, focused on pressures that hinder the research mission of higher education. In 1998, we turned our attention to competing for new resources and to ways to enhance individual and collective productivity. In 1999, we examined in more depth cross-university alliances. The focus of the 2000 retreat was on making research a part of the public agenda and championing the cause of research as a valuable state resource. In 2001, the topic was evaluating research productivity, with a focus on the very important National Research Council (NRC) study from 1995.

In the wake of 9/11, the topic for 2002 was "Science at a Time of National Emergency"; participants discussed scientists coming to the aid of the country, such as in joint research on preventing and mitigating bioterrorism, while also recognizing the difficulties our universities face because of increased security measures. In 2003 we focused on graduate education and two keynote speakers addressed key issues about retention of students in the doctoral track, efficiency in time to degree, and making

the rules of the game transparent. In 2004 we looked at the leadership challenge of a comprehensive public university to accommodate the fluid nature of scientific initiatives to the world of long-term planning for the teaching and service missions of the universities. In 2005 we discussed the interface of science and public policy with an eye toward how to move forward in a way that honors both public trust and scientific integrity. Our retreat in 2006 considered the privatization of public universities and the corresponding shift in research funding and infrastructure. The 2007 retreat focused on the changing climate of research funding, the development of University research resources, and how to calibrate those resources with likely sources of funding, while the 2008 retreat dealt with the many benefits and specific issues of international research collaboration. The 2009 retreat highlighted regional research collaborations, with discussion of the many advantages and concerns associated with regional alliances.

The 2010 retreat focused on the challenges regional universities face in the effort to sustain and enhance their research missions, while the 2011 retreat outlined the role of Behavioral and Social Sciences in national research initiatives. Our 2012 retreat discussed the present and future information infrastructure required for research success in universities, and the economic implications of that infrastructure, and the 2013 retreat discussed the increasing use of data analysis in university planning processes, and the impact it has on higher education and research. The 2014 retreat looked at the current funding environment and approaches which could be used to improve future funding prospects. The 2015 retreat addressed the opportunities and challenges inherent in innovation and translational initiatives in the time of economic uncertainty that have an impact on goals to enhance research productivity. The 2016 retreat focused on the building of infrastructure to meet the changing needs in research.

The 2017 retreat topic and discussions were on university research planning in the era of big data. The 2018 retreat topic and discussions were on big data and cross-disciplinary research. The 2019 retreat topic centered on challenges for implementation of cross-disciplinary research in the Big Data era. The 2020 retreat was cancelled in accordance with COVID pandemic public safety protocols.

Once again, the texts of this year's Merrill white paper reveal various perspectives on only one of the many complex issues faced by research administrators and scientists every day. It is with pleasure that I encourage you to read the papers from the 2021 Merrill policy retreat on Planning for Research after COVID.

Executive Summary

The Pandemic Appears to Be Waning: What's Next for Our Universities

Joseph E. Steinmetz, PhD
Executive Director, Psychological Clinical Science Accreditation System
Former Chancellor, University of Arkansas

- Spending an entire career in higher education has shown both good and bad. The resilience of universities is impressive, however, given how slow institutions can be in adapting to change. And universities continue to make significant contributions to society: research and discovery, teaching and learning, and outreach and engagement. Then came COVID-19. This paper describes the state of higher education prior to the pandemic, the challenges universities faced over the last year and a half, and predictions of the post-pandemic environment.

- The Great Recession (2007-2009) led to significant reductions in states' support of higher education and financial difficulties for many families. Yet most public universities adjusted and recovered relatively quickly. And while most would agree that research funding is inadequate, overall it has increased since the Great Recession. Generally, universities were in good shape prior to the pandemic but for four major concerns: 1. A financial model of state support and student tuition/fees that is not sustainable; 2. A change in student demographics from mainly white, middle and upper classes to poorer, more diverse populations; 3. The anti-immigration Trump administration affecting recruitment and status of international students, increasing racism and hate crimes, and stoking an "anti-intellectualism" and anti-science attitude; and 4. Equity issues in which higher education generally favors white students over disadvantaged students of color, as well as first-generation and poor students.

- From March 2020 to today, universities have taken financial hits; with revenue losses in fees, housing, dining, and athletics, there has also been expense increases for campus safety (Plexiglas barriers, masks, and vaccine-related costs). While faculty quickly shifted from face-to-face instruction to 100% remote, there were several struggles: some courses not suited for remote delivery, students prefer the classroom experience, and a differing opinion of quality and quantity of successful work-from-home arrangements. Other issues include the polarized political environment, state governance, deepening equity issues, and research grounding to a halt.

- After the pandemic has subsided, universities will need to address these conditions and make changes to build a strong future. Higher education institutions have always adjusted and met challenges; there is no reason to think universities will fail to meet the challenges exacerbated and created by the COVID-19 pandemic.

Post-Pandemic Research Innovations Contributing to Economic Development

Beth A. Montelone, PhD, Senior Associate Vice President for Research
Kansas State University

- At Kansas State University, nearly all research "hibernated" from March 2020 through June 2020. Work at the Biosecurity Research Institute (BRI) pivoted to new projects on SARS-CoV-2, once the viral sequence and samples were available. K-State then developed detailed plans for "reawakening" research with strict occupancy limitations and social distancing guidelines, which constrained activities in both laboratories and field settings. While the impacts of the hibernation have yet to be fully analyzed, there was speculation that researcher productivity would be negatively affected, particularly for parents, women, and underrepresented minority researchers.

- As the nation moves away from the pandemic, researchers and research administrators are looking to the future. K-State will continue building on its traditional strengths, fostering interdisciplinary work, and adhering to its land-grant mission to support communities and promote economic prosperity. To do so, K-State is aligned with the Kansas Board of Regents 2020 strategic plan and has chosen four focus areas: food and agriculture systems innovation, digital agriculture and advanced analytics, biosecurity and biodefense, and K-State 105. These development activities were built upon the process followed during K-State's successful pursuit of the Association of Public and Land-grant Universities *Innovation & Economic Prosperity* designation.

- This initiative will become part of K-State's 2025 strategic plan, will be focused on issues of primary importance to state policymakers and citizens, and will connect university efforts directly to the national and international marketplace. As with any other advancement, K-State of the 21st century will evolve at much greater velocity.

Exploring Differences in Androgen Deprivation Therapy Use for Prostate Cancer Between Black Men and White Men

Sally L. Maliski, PhD, RN, FAAN, Dean and Endowed Professor
in Oncology Nursing
Amy Garcia, DNP, FAAN
Ellen Harper, PhD, RN, FAAN
Francis Yang, PhD
University of Kansas School of Nursing

- Androgen deprivation therapy (ADT) is the standard treatment for metastatic hormone responsive prostate cancer (CaP) and is increasingly recommended as an adjuvant treatment with radiation therapy due to its survival benefit. Yet, it has been demonstrated that Black men are less likely to receive ADT compared to their White counterparts; and when they did receive it, the treatment was delayed compared to other men. The purpose of this study is to explore provider and patient factors related to ADT receipt between Black and White men in a midwestern health system. Using the EPIC Clarity database, identifying provider characteristics and ADT utilization/recommendation patterns, and exploring perceptions of and experiences with ADT in interviews, an explanatory framework will be created and used in future testing and development of practice guidelines and policy recommendations.

- A convergent, mixed methods design will be used to determine receipt patterns and type of ADT used, patient sociodemographics, and patients' interactions with providers. Candidates for ADT who had a combination of treatments will be identified, as well as those who did not receive treatment. Authorizing providers and their demographics will used to compare and contract treatment regimens. A Patient Advisory Board, consisting of community contacts and a prostate cancer support group, will assist in recruiting Black and White men eligible for inclusion in the interviews.

- The culmination of data collection and interview analyses will aim to produce a description of ADT utilization disparities and associated factors. The length of time from diagnosis to treatment will be compared, and provider characteristics will be identified through a latent class analysis. Data analysis and collection will run concurrently, then merged with the textual data from interviews to be examined and compared, evaluating if there is confirmation of or discordance between the men's perceptions and experiences with differences of ADT receipt patterns.

Lessons from the Department of Energy's Pandemic Response for Multidisciplinary Research

Julienne M. Krennrich, Director, Innovation Partnerships
James R. Morris, Ames Laboratory

- The hallmarks of science in the COVID-19 era include remarkable advances to address the pandemic, such as rapid genomic analyses and development and rollout of vaccines. Yet not all the challenges have been in the areas of biology and medicine. The U.S. Department of Energy (DOE) labs are driving multi-institutional and multidisciplinary research efforts, and their structure allows them to pivot and dedicate resources to accomplish significant results in a short timeframe. The Ames Laboratory (operated by the Iowa State University of Science and Technology) enables collaboration between ISU faculty and students and Ames scientists.

- A myriad of issues were raised when COVID-19 became a global pandemic in spring 2020, such as how to combine epidemiological modeling with human behaviors and economic modeling and how to provide the necessary medical equipment supplies where they were needed most. The CARES Act pushed research dollars to tackle these challenges. The DOE response was to create the National Virtual Biotechnology Laboratory (NVBL), which could be set up quickly due to the culture of multi-institutional collaboration between labs. The Ames Laboratory was able to tap into ISU's expertise to address the need for rapid on-site testing as part of the COVID-19 Testing R&D.

- The pandemic response demonstrated the DOE's ability to formulate "rapid response" groups of scientists that could devote significant resources and expertise to a mission-oriented (rather than academic-oriented) issue. National challenges are inherently multidisciplinary, and rapid change requires more than technical solutions. The key point is that the challenge drives the collaboration across fields. The DOE, and its National Laboratory system, seeks to nurture this culture, balancing mission-focused work with core expertise and capabilities.

Effects of the COVID-19 Pandemic and How We Adapted at the University of Missouri

Richard J. Barohn, MD, University of Missouri School of Medicine
Executive Vice Chancellor for Health Affairs,
Executive Director, NextGen Precision Health initiative

- The ALS Memantine Trial Study is a phase II study of the drug memantine (currently FDA approved for treatment of dementia) for patients with Lou Gehrig's disease to determine if the drug is safe in high doses, to explore the effect of the drug on blood biomarkers, and to detect if the drug could slow the progression of ALS. The COVID-19 pandemic had a significant impact on the approach and operation of the study. The protocol was adapted to enroll new patients and continue seeing enrolled patients remotely, using phone calls and video, as well as to maintain the collection of study data. Lessons learned under pressure of this pandemic will be useful in designing and conducting future clinical trials.

- By May 2020, the University of Missouri initiated a research restart plan and began reopening some laboratories and outpatient clinical research operations. MU investigators became involved with COVID-19-based research studies but encountered problems such as too few COVID-19 patients hospitalized at MU Health Care to recruit in each trial. That would change as the pandemic accelerated.

- Research expenditure growth and award dollars also were impacted due to the pandemic, and faculty began writing COVID-19 articles. One example, "Mandated Societal Lockdown and Road Traffic Accidents," determined if the stay-at-home policies led to a reduction in traffic accidents or fatalities.

- As the pandemic is still presenting challenges, more adjustments will be made. From a system level to an individual level, creative problem solving and meeting responsibilities for patient and community care have been hallmarks of the University of Missouri response.

From Office of Research to Office of COVID Response & Field Research in the Time of COVID

John P. Carroll, PhD, Director and Professor, School of Natural Resources
Bob Wilhelm, PhD, Vice Chancellor for Research and Economic Development
University of Nebraska-Lincoln

- Due to the COVID-19 pandemic, field research, an activity that must commonly plan for disruptions and unexpected events, had to be approached with even more creative and responsive efforts. As field research comprises a significant portion of the University of Nebraska-Lincoln's research portfolio, the university's response to the pandemic and continued field research are highly connected. A campus-wide task force was formed and coordinated specialized committees to address academics, research, facilities, etc. The leadership and staff of the Office of Research were also tasked with new operational duties.

- Strong restrictions were imposed in spring 2020, moving all academic programs to remote operations, curtailing all in-person events, and reducing research activities. The Forward-to-Fall committee was formed to plan for safe on-site activities for fall 2020. COVID-19 testing resources were organized, and a dashboard system was instituted. A majority of courses were offered with in-person options, and research continued with reduced density. The spring 2021 semester continued in the same manner.

- Field activities provide unique contrast to on-campus activities, and research outside of campus constraints is accompanied by elevated risk. Crop research, for example, faces broad weather vagaries, and researchers face uncertainties every year. It became clear field researchers and institutions were not as prepared to deal with a situation like COVID-19. Research location ownership resulted in a variety of rules and lockdowns, as well as guidelines on human and animal use and welfare considerations. Of particular concern were operational entities that require data harvesting from multiple sites, such as the groundwater well monitoring system for Nebraska.

- The most critical component of research enterprise is the workforce, and the most vulnerable identified as graduate and post-doctorate students. Communication was critical as these positions are time dependent and tied to contractual responsibilities. Despite the lack of planning for a pandemic of this magnitude, the strategies developed in the last 18 months minimized the impact on researchers while ensuring the safety of faculty, staff, and students.

Junior Faculty Research Career Development in the Era of COVID-19

Kimberly Kirkpatrick, University Distinguished Professor
Department of Psychological Science
Kansas State University

- The fundamental mission of the Centers of Biomedical Research Excellence (COBRE) grant that established the Cognitive and Neurobiological Approaches to Plasticity Center (CNAP) is to develop faculty research careers with an emphasis on securing R01-level extramural research funding. CNAP researchers study cognitive and neural plasticity in animal models and conduct basic and clinical research in humans. Faculty is supported by two funding mechanisms: research grant projects and pilot grants.

- CNAP faculty have access to outstanding core facilities and cutting-edge technologies and techniques. The faculty development model involves five pillars of success to support junior investigators: an active grant-seeking culture, outstanding mentoring program, grant writing program, advanced computational modeling, and modern neuroscience techniques.

- When COVID-19 unfolded, CNAP was entering the final quarter of Year 3: one investigator had graduated to R01 status, three had received extramural grants, and one had received an R21 competitive score. The program was on track to have COBRE grant renewed for the second phase. However, the effects of COVID-19 for CNAP-supported research were profound; human and animal research was strongly impacted, and laboratories were heavily affected. These adverse effects were not surprising because of the reliance on access to often vulnerable populations and specialized equipment in this discipline.

- CNAP began a COVID-mitigation strategy, first granting a no-cost extension for grants scheduled to end in May 2020, then using central funds to partly fund a technician's salary in a senior faculty's laboratory. The most extensive strategy was the months-long transition of human research to a remote testing format, which ultimately enabled researchers to work with vulnerable populations much more quickly.

Post-Pandemic Directions for Aging Care Research

Kristine Williams, E. Jean Hill Professor
University of Kansas School of Nursing

- The COVID-19 pandemic changed the world for everyone, but older adults were disproportionately affected. As the nation emerges from the pandemic, improving ongoing aging care must take precedence. Positive changes such as telehealth should be expanded, and measures to reduce infection and isolation identified and implemented. Nursing homes have been slow to adopt improvement initiatives that are critically needed. This paper pinpoints directions for research to leverage improvement in care for older adults in the post-pandemic world.

- Infection control, a priority for nursing home care during the pandemic, consisted of personal protection equipment and isolation precautions. While these protocols prevented more resident deaths, they also led to lack of socialization and increased residents' loneliness, depression, and anxiety. Research is necessary to explore opportunities for improving infection control, such as private resident rooms or pods, technology and telemedicine, and staff training.

- Rethinking nursing homes in favor of more community-based models has been suggested. However, policy and current reimbursement barriers must be overcome. An estimated one in five Americans provides care for adult family and friends at home. Research is critical on how to best support these families and must address other approaches to reduce reliance on nursing home care. The COVID-19 pandemic provides a wake-up call to overcome old challenges and develop new solutions in providing quality nursing home care.

What's Past Is Prologue: A Research Response to a Pandemic Tempest

Peter K. Dorhout, Vice President for Research
Iowa State University

- The Coalition for Epi Response, Engagement, and Science (CERES) mission is to protect and defend the agricultural industry against global threats, respond to and recover from outbreaks, and provide innovations for food security. In January 2020, CERES was planning its spring advocacy meeting, while attention was focused on an emerging zoonotic disease threat in Asia. By the February meeting, over 130 cases of COVID-19 had been confirmed in the U.S. Within three weeks of that meeting, cases had increased over 200 times, and universities were preparing to shut down all operations, including research. Evaluations were already taking place to understand the unique genetic composition, and a vaccine candidate entered Phase 1 clinical trials by mid-March 2020. In the history of our knowledge of viruses, there has never been such a rapid response to an infectious invader.

- Past experiences with global pandemics—1918 influenza, 1957 "Asian" flu, and 1983 AIDS—are a prologue of the next act in infectious diseases. In the late 19th century, average life expectancy in the U.S. was fewer than 40 years. Then Joseph Lister recognized the importance of sanitized hands and equipment in medical procedures. Robert Koch became the father of medical bacteriology and developed a potential treatment for tuberculosis.

- At the time of the 1918 influenza outbreak, a new generation of bacteriologists and virologists was emerging, such as Oswald Avery and later Gertrude Elion, who would discover new realms of science through their scientific choices. Their contributions represent examples of how research from the past serves as prologues to the present. Investments in fundamental science will continue to shine a light on the diversity of pathogens we may confront and how to do battle with them.

- There are challenges ahead for global research enterprise, namely funding, differences in access to treatments, and education. Higher education leadership must create environments of inclusion and equity. The future of invention and innovation must include diversity of thought. Different perspectives, views, and experiences must be part of our scientific lexicon.

The Pandemic Appears to Be Waning: What's Next for Our Universities

Joseph E. Steinmetz, PhD
Executive Director, Psychological Clinical Science Accreditation System
Former Chancellor, University of Arkansas

I have spent my career in higher education, including my student years, time as a faculty member conducting research and teaching in my field of behavioral neuroscience, and 26 years as an administrator. Those 26 years consisted of service as chair of the Department of Psychology at Indiana University (1995-2004), an associate dean at IU (2004-2006), dean of the College of Liberal Arts and Sciences at the University of Kansas (2006-2009), executive dean of Arts and Sciences and then executive vice president and provost at Ohio State University (2009-2015), and most recently chancellor of the University of Arkansas (2016-2021). During my time as an administrator, I saw my share of good and bad times in higher education. I think the good times far outweighed the bad times. Indeed, the resilience of our universities through rather significant changes in higher education—such as the development of new technologies, economic recessions, fluctuations in federal support for research, rapidly growing enrollments and several other major influences—has been impressive, especially in light of how slow our institutions can be in adapting to change. Nonetheless, our universities continue to make contributions to society through our missions of research and discovery, teaching and learning, and outreach and engagement. Then came the pandemic that hit the world in February of 2020.

In this paper, I will provide my insights into what I believe are the effects of the pandemic on our universities. I will briefly describe the state of higher education at the time the pandemic struck, summarize the challenges universities faced during the pandemic, make some predictions on what the post-pandemic environment will look like, then close with some reasons why I believe we should be optimistic about the future of higher education.

For full disclosure, I resigned as chancellor of the University of Arkansas in June of 2021, after serving five and one-half years in the position. While there are always several factors that go into a difficult decision like this one, there were a few things that significantly impacted my thinking when I resigned (https://www.chronicle.com/article/whispers-to-rumors-to-resignation-u-of-arkansas-chancellor-resigns). Like many university administrators, the pandemic frankly wore me out. I can cite a variety of reasons for why this was the case. Universities should be a place where ideas are welcomed and debate about those ideas civil. It's this environment that I valued and enjoyed in my various leadership positions; this is what makes universities special. Sadly, I don't think this is the case anymore.

As the national political climate has polarized, so have discussions on campuses, and this has made the campus CEO position extremely difficult. And Arkansas is a very "red" state, where views of conservative legislators and members of the university community are often very different and therefore often clash. Particularly during the first six months of 2021, I often felt trapped between these polarizing sides, knowing that whatever decision I made, I would anger one side or the other. I received more "demand" letters and formal resolutions over the time of

the pandemic than probably the prior 25 years I served as an administrator. People no longer approached issues from a "let's talk about this" manner but now a rather hardened "we demand" position. For the last several months I served as chancellor I often dreaded coming into the office because I knew there was likely another issue that I would have to deal with—this is crisis management, not strategic leadership, which I enjoyed.

Lastly, and possibly most importantly, I lost passion for the job, passion that has driven me over the 26 years I have been an administrator. At many of the commencement ceremonies I presided over as chancellor I told the graduates to find a career and calling that they were passionate about and not to settle for anything less. It was clear that I had lost my passion for the work I was doing—it was time for me to heed my own advice. So, I decided to step down as chancellor, a decision I thought best for me and for the institution.

The Pre-Pandemic State of Higher Education

Over the last few decades, arguably one of the most impactful events to affect higher education was the Great Recession caused by the burst of the U.S. housing market and a global financial crisis that lasted from 2007 to 2009. For public universities, the Great Recession led to significant reductions in states' support of higher education, as well as financial difficulties for many families. While there have been steady increases in state support over the last seven to eight years, adjusted for inflation, public universities are still receiving less than they did before the Great Recession (https://www.cbpp.org/research/state-budget-and-tax/state-higher-education-funding-cuts-have-pushed-costs-to-students). However, it seems that most public universities adjusted and recovered from the recession relatively quickly, in part by maintaining enrollments and raising tuition to backfill the losses of state support. For example, at four-year public universities tuition increased 37% between 2008 and 2018 (https://www.cnbc.com/2019/10/24/college-costs-have-increased-in-all-50-states-over-the-past-10-years.html). While most universities agree that research funding is inadequate, overall research funding increased since the Great Recession. For example, the National Institutes of Health appropriation increased from $31.2 billion to $41.7 billion between 2010 and 2020 while the National Science Foundation appropriation increased from $6.9 billion to $8.3 billion during that same period (https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd). All in all, I believe our universities were generally in good shape prior to the pandemic. With that said, there are at least four major areas of concern that universities were facing before the onset of the pandemic.

1. A Financial Model That Is Not Sustainable. For many years, public universities used the same model to support their operations, a combination of state support and student tuition and fees. This model is no longer sustainable. States have steadily reduced their funding for higher education over the last 20 years. The University of Arkansas serves as an example. In 2000, about 70% of the U of A budget was supported by dollars appropriated by the state and roughly 30% by tuition, fees, and other small sources of revenue. By 2018, that ratio more than flipped with less than 18% of the budget coming from state appropriations and about 72% coming from tuition, fees, private dollars, and other sources of support. While there are many reasons most states have reduced their support for higher education, I believe a major reason is that public education is no longer considered a public good, but rather a private good that benefits individuals more than society in general. In essence, the lost state dollars have been

made up by increasing tuition and fees to the point where many families cannot afford to send students to college. Indeed, college cost increases have outstripped small gains in household incomes, and student debt has increased significantly. This trend cannot continue so universities must create a new financial model to survive. Other sources of revenue must be found, such as partnerships with the private sector, and universities must become more operationally efficient. Also, new ways to support research will have to be part of the model because all universities subsidize their research operations from general funds that include state dollars and student tuition.

2. Changing Student Demographics. For many years, major research universities have drawn students from mainly the white middle and upper middle classes and less from poorer, more diverse areas of our country. Population experts, however, predict a change in student demographics that could impact our public universities in what many are calling an "enrollment crisis" (https://www.cupahr.org/issue/feature/higher-ed-enrollment-cliff). This trend was evident before the pandemic began. Of note is the fact that the national birthrate has been declining since 2008, meaning fewer high school graduates will be available moving forward; this is particularly evident in the North and East (less so in the South and West). And most of the decline has been in the white population. Some are predicting that by the mid-2040s, we will be a "majority, minority country." These trends mean that for public universities, the traditional students who have been recruited are declining. This could significantly impact enrollments at many universities. It is interesting to note that increases in enrollment for major research universities, especially in the South and West, are predicted. I believe it would serve our research universities well if they took steps to increase admission, retention, and graduation rates of students they have not traditionally enrolled.

3. Four Years of the Trump Administration. Donald Trump was elected president in 2016 before the pandemic began, and his administration and policies certainly affected higher education, mostly, in my opinion, in negative ways. Let me cite just a few examples.

First, the Trump administration was anti-immigration for the most part and this affected the recruitment and status of international students. It became harder for international students to enter (and stay) in the country, so universities saw a decline in the number of international students matriculating in the U.S. This had three very immediate effects: Revenue generated by tuition paid by these students fell. Other countries such as England, Canada, and Australia became more successful at recruiting these students, and this is likely to cause long-term effects on the relative competitiveness of U.S. universities in attracting students. And, perhaps most importantly, there has been a loss of valuable talent entering the U.S., talent that is particularly valuable for our research enterprise, as well as private sector employment.

Second, there was a major shift in how Title IX cases were viewed and handled as the regulations around Title IX shifted. Under the Obama administration, great care was taken to protect the complainant before, during, and after Title IX proceedings. Under the Trump administration, new regulations were written, including changes in the hearing process and a general shift of focus onto the rights of respondents. These changes resulted in the need for universities to increase the number of staff members working in the Title IX area. In addition, an increase in the number of suits and legal cases by respondents against the universities has

been seen. I believe that universities successfully adjusted to the changes, however, and that the process continues to be fair to both parties involved. It is likely, though, that the process will change again as the Biden administration issues its directives.

Third, for the last several years the general respect and sense of importance of higher education by the public has been diminishing and this accelerated during the Trump administration, in part due to the negative attitude the administration had on higher education (e.g., Trump's threats concerning the University of California, Berkeley around issues of free speech). Many in this country are now questioning whether a college education is worth it. This is due, in part, to the accelerating cost of a college education (which is our fault). But there is a political angle, as well. Colleges and universities are generally considered by the political right to be very liberal places (which, for the most part, they are) that negatively influence the thinking of students (which there is no evidence for). This position has influenced the views of the general population. For example, even though it has been well established that college education increases earning potential, overall satisfaction with life, voting rates, and several other variables, a Gallup poll conducted in 2019 revealed that only 51% of respondents rated a college education as very important, which is an all-time low. Importantly, the biggest shift in responses was in young adults (18-29 years old); eight years ago, 74% rated college as very important, whereas last year that number dropped to 41%. Attitude toward the importance of college does depend on your party affiliation. Some recent data from Pew showed that 67% of Democrats had a favorable view of higher education, with 18% holding a negative view (https://www.pewresearch.org/social-trends/2019/08/19/the-growing-partisan-divide-in-views-of-higher-education-2). For Republicans, 33% had a favorable view while 59% held a negative view. Reflecting the attitude of the political right on colleges and universities, mistrust of the "liberal agenda" seems to drive the negative attitude. These numbers should be of concern to higher education.

Fourth, during the Trump administration there was a general empowerment of some factions in society that were hidden and, for the most part, silent over the last several years. The increase in hate crimes, racism, and what I think of as a general "anti-intellectualism" grew over the last four years. This became evident to me the day after Donald Trump was elected: I received reports of many racist remarks being openly directed toward international students and students of color at the University of Arkansas the day after the election. While the campus was never truly free of these remarks, the incidents increased significantly to the point of making many of our students feel unsafe and unwelcome. Regarding the anti-intellectual climate in this country that has developed in recent times, one only needs to look at our response to the pandemic and this country's general lack of trust in science to deal with the worst health crisis we have seen in a century. Many chose to follow the advice of social media "experts" and politicians rather than scientists and public health experts, and this attitude continued even after effective and safe vaccines became available. The Trump administration did very little to engender trust in these experts, and I believe this fed the "anti-intellectual" movement that started years before.

4. Equity Issues in Higher Education. Even before the pandemic there existed an issue of equity around access and affordability of a college education. Simply put, higher education has generally favored white students from certain geographical areas that have access to good

schools, college test preparation services, and the resources to attend college. The system has disadvantaged students of color, as well as first-generation and poor students, who have neither the access to K-12 education equivalent to their affluent peers nor the financial means to attend college. Our major research universities have tended to admit elite students with high ACT or SAT scores, a solid K-12 education, and the financial means to pay the higher tuition generally charged. Poorer students have tended to go to regional colleges and universities (if they go at all). Don't get me wrong, these regional universities can and do provide excellent education (I am, in fact, a product of this education—thank you, Central Michigan University). But there is a large difference in how much is spent per student in these two kinds of public universities, as well as a large difference in outcomes (i.e., retention and graduation rates). Given the general shift in demographics discussed above, this equity issue needs to be addressed.

Issues Universities Faced During the Pandemic

Higher education, like all aspects of our society, was not prepared for the global pandemic that took hold in March of 2020. It hit harder and has lasted longer than most predicted and caused unprecedented issues for our universities, leading to a major disruption of our basic missions of teaching and learning, research and discovery, and outreach and engagement. For me, the seriousness of the pandemic became apparent while I was attending the Southeastern Conference President's and Chancellor's meeting and men's basketball tournament in Nashville, Tennessee. Within the span of 24 hours, the meeting was suspended, the tournament halted, and I enacted a series of decisions on how to deal with the pandemic on the University of Arkansas campus. The first of those was to essentially shut the campus down, pivoting to a 100% remote learning environment for our students and a work-from-home situation for our faculty and staff. I, like many others, did not think we would be dealing with the pandemic through the summer of 2021 (when I wrote this piece). Summarized here are some of the major issues that our universities faced during the pandemic.

1. Universities Took a Financial Hit. While only a few universities reduced tuition during the pandemic, many decreased fees, and there was a significant loss in revenue in auxiliary operations such as housing, dining, and athletics. At the University of Arkansas, we did not furlough faculty or staff or reduce hours, so personnel costs continued even though significant revenue was lost. We were also fortunate that we did not see an enrollment drop during the fall of 2020 even though we continued to deliver our courses mostly remotely. This was not the case nationally as student numbers fell during the 2020-21 academic year. There was also concomitantly an increase in expenses. These expenses include equipment and supplies to deal with keeping the campus safe during the pandemic (e.g., personal protective equipment, extra campus cleaning, Plexiglas barriers, masks, and vaccine-related costs), as well as a significant investment in technology to enable us to deliver courses remotely and in person when possible. The three federal subsidies to universities helped reduce this financial hit, but in the end the loss of revenue and addition of expenses were still greater than the federal assistance for most universities. I should also mention that a loss of jobs during the pandemic had a significant impact on the financial situation of our students and their families.

2. Popularity and Quality of Remote Courses. I was amazed at how adaptable our faculty was in shifting from a traditional face-to-face mode of instruction to a 100% remote environment; they

stepped up and did well. However, some of the faculty struggled, some courses were not suited for remote delivery (e.g., art, architecture, music), and some of our students struggled to adapt to this format. In fact, one thing we learned during the pandemic is that overall, our students didn't like taking their courses remotely; they came to the university for the classroom experience and not to sit in their rooms in a remote class. There were many calls for tuition rebates across the country, which indicates that our students don't see remote delivery as equal value to traditional courses. And many faculty members are concerned that there may be knowledge gaps going forward, as it's hard to assess whether the remote experience created the same learning experience as traditional course delivery—I doubt it did.

3. Staff and Faculty Pivoted to Working at Home. While work-from-home opportunities have been around for business and industry for the last several years, they have largely not been available in higher education. Except for a few essential workers, for the duration of the pandemic our faculty and staff worked from home for over a year, only returning in larger numbers in June of 2021. This arrangement did keep the campus safe during the pandemic. There is a difference in opinion between supervisors and those staff and faculty working from home on the overall quality and quantity of the work. Our faculty and staff believe they were as effective at home as on campus (and many want to continue this arrangement indefinitely). Some supervisors disagree and believe there was a slight drop-off in productivity of people working from home. This may, in part, be due to the type of work. Some jobs can be done effectively while remote, such as some financial and HR related jobs. Other jobs require face-to-face contact with the students and others on campus; these positions are not candidates for continuation of remote working arrangements.

4. Polarized Views of Students, Parents, Faculty and Staff on the Seriousness of the Pandemic. A major reason the pandemic has lasted for as long as it has is that a polarized view on the seriousness of the COVID-19 virus has existed since the pandemic began. This was evident in the communications I received from students, parents, faculty and staff throughout the pandemic. From the day we made the decision to go 100% remote for teaching and research in March of 2020 until the day I stepped down as chancellor, it was common for me to receive contrasting e-mails within the same hour. I received angry emails from students and parents challenging my decision to go remote for classes and mandating masks and physical distancing for those classes and functions being held on campus—it was common to hear from this group that the virus was a hoax or that it only affected old and sick people. On the other hand, I received many emails from nervous faculty and staff blasting me for not keeping the campus safe enough. This group wanted no in-person classes, as well as mask mandates, vaccine mandates, and maintenance of physical distancing for all situations even after the vaccine became widely available. In other words, this group would shut everything down and keep it shut down until the virus disappeared. I rarely heard from people who thought what we were doing was a good course of action.

5. The Emergence of a Severely Polarized Political Environment. I cannot think of another time in my lifetime when there has been more political polarization than currently, and this has affected our universities, especially during the pandemic. It doesn't matter the issue—the pandemic, immigration, Title IX, social justice—our country is deeply divided. This means that our universities had to deal with this

polarized environment in setting policy, curriculum, research and more. In some states, like Arkansas, one political party holds a super-majority so there is little if any compromise on any issue. This puts universities in very difficult positions as they try to balance the views and needs of students, faculty, staff, and alumni who hold many different perspectives.

6. State Governance. Even though support for higher education has decreased in virtually every state, state legislators and governors have not reduced their desire to exercise control and oversight of universities. In fact, I believe that this oversight has increased over the last several of years. With this climate as a backdrop during the pandemic, particularly in deeply "red" states like Arkansas, new laws and statutes were passed that have had a significant impact on public universities. And this impact is largely negative. In Arkansas for example, new state laws were passed that targeted transgender people and how they can participate in sports. Two laws were passed that made it more difficult for the university to deal with the pandemic; one law forbid mask mandates while the second law forbid vaccine mandates. Both laws limited how the university could deal with the pandemic. New freedom of speech laws were established during the pandemic that were largely unnecessary.

And a bill preventing universities from removing or moving statues, building names and monuments was adopted. This bill was triggered, in part, by a discussion on the University of Arkansas campus concerning the legacy of William J. Fulbright, a former student, U of A president, and U.S. Senator. While Senator Fulbright certainly had a significant, positive impact on the country through his opposition to the Vietnam War and establishment of the Fulbright Foreign Exchange program, he was also a segregationist who signed the "Southern Manifesto" and failed to vote in favor of the civil rights bill (see Woods, 1995, for a comprehensive review of the Fulbright legacy). This mixed legacy created a split on campus with many suggesting a statue located in a prominent place on campus be removed along with his name from the College of Arts and Sciences. State legislators were incensed with the idea that the statue would be moved or removed. The legislation made neither of these options doable, even though I recommended that the statue be moved to a location on campus where the Senator's life could be historically contextualized. It was difficult enough to manage the university during the pandemic. Legislation such as cited above made it even more difficult. And this situation was not unique to Arkansas.

7. Deepening Equity Issues. We entered the pandemic with inequities in access and affordability to higher education as a serious issue. The pandemic magnified this issue. Students struggling to pay for their college experience were hit hard as many had to work two and even three jobs to remain in school; these jobs disappeared during the pandemic, making paying for college even more difficult. Inequity of accessing good healthcare was another issue exposed during the pandemic, as was access to technology. As our students went home, we discovered that many didn't have good internet access, making remote course work difficult or impossible. It was clear that many of our students of color were affected worse than our white students, thus deepening the existing equity issues.

8. Faculty Were Impacted. During the pandemic I had many discussions with other chancellors and presidents on how the virus was affecting their campuses. All reported that their faculty were concerned about how the university was handling the pandemic and expressed feelings of fear and anxiety about returning to campus even when the vaccine was widely available. Faculty senates

across the country forwarded numerous petitions on a variety of topics, including mask mandates, vaccine mandates, COVID-19 testing mandates, reinstatement of in-person classes, compensation increases for the pivot to remote learning, and suggestions that remote teaching be a permanent option for faculty. Further, many of us campus leaders seemed to get an increase in communications indicating we were not doing enough to battle the pandemic or social justice issues or to respond to state legislators who were passing laws that negatively impacted the university. The pandemic did impact the faculty significantly, especially our more junior colleagues. For example, many institutions stopped or delayed the tenure clock in recognition of the negative impact of the pandemic on research and teaching; many untenured faculty are very nervous about their upcoming reviews.

9. Research Was Impacted. Research ground to a halt as physical distancing and remote work requirements kept researchers home and not on campus. Libraries were closed. Graduate students working on research projects saw their scholarship stopped. Research funds were not used, presenting problems for maintaining infrastructure and other issues. It will be several years before we completely understand the impact the pandemic had on our university research enterprise in this country.

10. Crisis Management Mode. Arguably the biggest impact of the pandemic on me was that I felt I was nothing more than a crisis manager for the university instead of thinking about strategic planning and the long-term vision for the university. I seemed to be in a mode of dealing with the crisis of the day. Many things in the planning stage were placed on hold for financial or time-constraint reasons. This was not good for the long-term health of the institution.

Post-Pandemic Issues

At the time of writing (September 2021), the pandemic is again surging across the country, and it is clear that universities will go through another academic year dealing with COVID-19 and its variants. When we eventually emerge from the pandemic, there are many issues that our universities will face. Some of these existed before the pandemic, some were worsened by the pandemic, and some were created by the pandemic. I present some examples here.

1. Development of a New Financial Model. As I indicated, the current financial model on which public universities operate is not sustainable. This issue still needs to be addressed and must now include a post-pandemic financial recovery period that deals with pandemic-related revenue losses and expenses and places universities on a stable financial footing moving forward. This new financial model must also reflect the changing student demographics.

2. Unsolved Social Justice Issues. While the George Floyd murder exposed equity and inclusion issues in this country and universities took steps to deal with these issues, as a society we are a long way from true equity for all in this country, including in our universities. I don't believe these issues will fade to the background as they have in the past, but rather remain front and center until solved. Our universities should be on the front line in these efforts.

3. Athletics. Just as our financial model is not sustainable, neither is our current model of college athletics. Budgets for athletics departments have gotten out of control, driven mainly by television revenue and deals with promotional companies. While dollars spent on athletes has increased, much of the additional dollars have gone to coaches and administrators. This has resulted in the creation of the "haves and the have-nots" in our universities, with the so-called Power 5 conference schools having seemingly unlimited funds while schools in other conferences

struggle to remain competitive. At many colleges and universities, the general student body may be the real loser, as many schools have adopted student fees or diverted general fund dollars to subsidize their athletic programs. This situation could get worse as coaches' salaries appear to still be rising, conferences are realigning to maximize revenue, and issues concerning the use of an athlete's name, image and likeness will likely change the recruiting landscape. The future of the NCAA seems murky, at best. This overall situation will present challenges for universities in the post-pandemic world.

4. The Shared Governance Model. One thing I have always enjoyed about working at a university is that governance of the university is shared between the administration, faculty, staff, and students. Traditionally, faculty have a large voice in the operation of the university. This is very different from a corporate model where there is little input outside the people who run the corporation. I believe this model may be threatened in the future for several reasons. Increasingly, non-academics with no experience in higher education are being chosen as campus CEOs. Faculty senates, who provide input into the shared governance system are not always representative of the faculty at the university—it is therefore difficult sometimes to ascertain if the input reflects the will of the faculty in general. It is my experience that some faculty don't always have a grip on what is going on in the "real world," perhaps in part due to the relative insulated nature of a college campus. The divide between faculty and legislators and board of trustee members seems to be widening. One can see this in the increasing calls for the elimination of tenure seen over the last few years by people outside of our universities—these individuals simply don't know or understand how a university functions. For shared governance to continue to prevail I believe that administration must become more inclusive in decision making, and faculty must become more flexible regarding how universities operate. This became particularly clear during the pandemic.

5. Governing Boards. In nearly all universities and colleges, the ultimate oversight of the institution is in the hands of governing boards, such as Boards of Visitors, Boards of Trustees, or Boards of Regents. Over the course of my time in administration, I have seen a gradual increase in attempts for these boards to manage the day-to-day operation of the university instead of the more global, overarching governance role they should be playing. A good recent example of this overreach was the interference of the system governing board of the University of North Carolina at Chapel Hill in the hiring of renowned journalist Nikole Hannah-Jones to a named chair position (https://www.chronicle.com/article/what-the-hell-happened). While UNC wanted to hire her as a member of the faculty, her hire was rejected by the governing board for political reasons—she was involved in the development of the 1619 Project of which the political right holds a dim view. Why was the board's action significant? It was a clear demonstration of interference in academic matters, which traditionally have been given to faculty at an institution. Academics depend on peer review, not politics, to determine whether an idea is good, and this should apply to the 1619 Project—historians will determine if the ideas of the project are good or bad. I am not surprised by the rising involvement of boards in the micromanagement of universities. Many boards are political appointees, elected positions, or prominent alumni of the university. Knowledge of how to govern a university is not always the criteria for appointment so it doesn't surprise me that their involvement becomes focused on individual issues about which they are passionate, including politics, athletics, fraternities and sororities, campus parking, and a host of other issues

that campus CEOs typically don't believe are the most important issues.

6. Research Funding. Research and discovery at our universities essentially ground to a halt during the pandemic as access to laboratories and libraries was difficult. This led to a reduction in research expenditures at most universities. When the pandemic has subsided, there will have to be a period when the investigators attempt to catch up and get their research programs back on track. Graduate students have been significantly affected by the pandemic, as well as their progress toward their degrees, thus delaying their graduation and start of their careers. This delay has affected incoming students; spots in graduate programs normally freed through graduations are occupied. The same can be said for postdoctoral fellows and perhaps new assistant professors as hiring has been delayed somewhat during the pandemic. Some adjustments will have to be made post-pandemic. While research funding has been relatively good over the last decade, I do have concerns about research funding in the future. We must remember that federal funding for research is considered "discretionary" funding. The federal government has spent a lot of money dealing with the pandemic in the recovery acts as well as development of the vaccine. In addition, rather large funds have been approved lately for infrastructure and other needs. Together, these new expenditures have increased the federal deficit significantly. I am concerned that at some point this deficit will be addressed, not through raising taxes but rather through cuts in the discretionary funding. This could put research funding at risk in our post-pandemic world.

7. Succession Planning. As I indicated above, I chose to step down as a campus CEO after the vaccine was made available and as the university began to emerge from the virus. I admire greatly campus CEOs who have continued during this chaotic period. I know a lot of other presidents and chancellors who are contemplating resignations after the pandemic. I predict that there will be a lot of campus CEO vacancies after the pandemic and perhaps not enough individuals with administrative experience to fill the positions. Universities will have to deal with this issue. I, like many other campus CEOs, had a rather traditional academic pathway to the chancellor's position, serving as department chair, dean, and provost prior to taking the campus CEO position. Fewer academics are taking this route these days and that means campus leaders will likely come from other places and have other experiences. The learning curve for these leaders will be steep.

Some Reasons for Optimism

Much of what I have written here is a rather pessimistic view for the post-pandemic future of our universities. Even though I have decided that I no longer want a role as an administrator at a university, I am very optimistic about the future of our public universities, especially our leading research universities. Here briefly are 10 reasons for optimism:

1. Higher education has faced previous challenges and has effectively addressed them. Universities have changed over the years to meet challenges they faced. Examples are the rapid growth of students after the G.I. Bill was enacted; rapid growth of research and scholarship; anti-tenure movements; campus protests on a variety of topics such civil rights, the Vietnam War, and free speech; and a huge financial crisis in 2009. Universities adjusted and met those challenges, and there is no reason to think that universities will fail to meet challenges created or exacerbated by the pandemic.

2. The pandemic showed that students still want a residential campus experience and are not satisfied in a remote learning world. For years, I have read articles predicting the demise of the brick-and-mortar campus and the increased desire of stu-

dents for totally online experiences. Feedback I received from students and from my colleagues around the country is that our students missed the experiences they get on a college campus, including social and cultural events, residence hall living, Greek activities, athletics, bonding with other students, and the outside-the-classroom educational experiences in which they seek to participate, such as research and service-learning opportunities. Universities are much more than the classes students attend and for this reason our public universities have a bright future—residential universities are still relevant.

3. I have often said that the quality of a university is primarily determined by the quality and dedication of the faculty. I do not believe that the pandemic has in any way diminished the enthusiasm or dedication of our faculty to our basic missions of teaching and learning, research and discovery, and outreach and engagement. Across the country our faculty came together in remarkable ways to provide learning opportunities for our students during the pandemic. The core values of our faculty remain strong, and this is good for the future of higher education.

4. In every administrative position I have held, I have stuck to the belief that to improve as a university you should hire faculty who are better than the existing faculty. Indeed, the future of our universities depends on the new faculty we hire. I am very optimistic about the future because the faculty we are hiring at our institutions are outstanding. In my view, they are dedicated to the mission, hungry to succeed, well educated, experienced, flexible, and more collaborative. Above all, our newest faculty, unlike some of their more senior colleagues, seem more willing to try new things and do things in new ways. This will be important in the post-pandemic world as universities strive to meet some of the challenges I outlined above.

5. The need for higher education is as great now as it has ever been if not arguably even greater. Jobs are more complex than ever, and companies are looking for employees with good communication and problem-solving skills and who can think creatively, which should be the result of a good college education. There is a growing need for post-baccalaureate education in the forms of certificates or advanced degrees as employers and employees seek to extend skill sets after an individual has been hired. Universities must step up to offer these educational opportunities before the private sector decides they can assume these responsibilities without the expertise that universities offer. Finally, there are many vexing problems in the world, such as climate change, which can only be addressed through research. Universities provide the country's premier research platform and as such the need for university research has never been greater.

6. I believe that universities are taking social justice and equity issues more seriously than ever before and this is good for all. In the past, attempts have been made to promote a sense of inclusion or belonging within our universities, but the social justice movement energized by reactions to the George Floyd murder and other recent events has instilled a new purpose in universities to address these issues of inequity through education, as well as concrete steps to promote inclusion. I am very hopeful that this issue will remain on the front burner and not simply addressed in the short-term, then shunted aside, which has happened in the past.

7. One thing that has baffled me for years about universities is that members of most university communities either resist change or are slow to change. While some of the brightest individuals in the world work at universities and generally embrace change in their own scholarly disciplines, these same individuals resist change in the operation or organization of the university. I don't know

how many times I have heard the phrases "We have never done it that way" or "If it isn't broke, don't fix it," even when there may be better or more efficient ways to do something or to be organized. But the pandemic proved something to me: Universities can be nimble, quick, and flexible as evidenced by the rapid shift to remote learning that was seen and rather quick adjustments that were made after severe changes in operation and the academic environment. I am hopeful that this lesson learned will be extended post-pandemic, and that our universities become known for their ability to be agile and nimble instead of the current perception that universities are places that resist change and are slow to adapt to the "real world" changes around them.

8. Technology continues to advance rapidly, and during the pandemic our universities showed an ability to adopt and use that technology to continue our teaching and research missions. I believe universities will continue to be at the forefront of the development of technology, as well as find creative ways to use new and existing technology to advance the important missions of the university. Universities must figure out how to maximize use of new technology to benefit their missions.

9. There is currently a great need for universities and the private sector to partner for the benefit of both. Businesses are increasingly looking to partner with higher education on teaching and research projects, and I am confident that our research universities will participate in these collaborations. This will require give-and-take on both sides as the academic environment and business environment can be quite different. These partnerships may also provide the framework for a new financial model moving forward.

10. Finally, a bit of what I discussed above was based on our current political environment. We recently endured four years of a president's administration that was not friendly to higher education and at times was clearly confrontational. And many of our states currently are governed by individuals with similar thinking. But our history has shown that politics always change as the pendulum swings between right and left. This fact makes me hopeful for the future of higher education. We have survived political shifts before, and we will indeed do so again. I hope we can reach middle ground eventually where compromise is possible.

I close with this: There were several issues facing higher education before the COVID-19 virus took hold around the world, issues that needed to be addressed for universities to thrive. It seems to me that the pandemic exacerbated these issues while creating a few more that need to be addressed over the next several years as the world emerges from the pandemic. But I am quite optimistic that our universities will solve these issues and others that become apparent and will continue to change lives, solve complex problems, and make a significant impact on the world.

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Post-Pandemic Research Innovations Contributing to Economic Development

Beth A. Montelone, PhD
Senior Associate Vice President for Research
Kansas State University
102 Fairchild Hall
1601 Vattier Street
Manhattan, KS 66506
https://orcid.org/0000-0003-2992-4007

The COVID-19 pandemic had an undoubted effect on university research, with most U.S. institutions temporarily shutting down most on-site research activities in March 2020 for three months or more, followed by a slow and phased approach to reopening (Wigginton et al, 2020).

At Kansas State University, nearly all research "hibernated," apart from activities deemed essential to complete ongoing, time-sensitive studies or infectious disease work at our College of Veterinary Medicine and Biosecurity Research Institute (BRI). Hibernation lasted from March through the end of June 2020. During this time, work at the BRI, a BSL-3 and BSL3-Ag facility, largely pivoted as studies were completed to new projects on SARS-CoV-2, once the viral sequence and samples became available.

The BRI also reached an agreement with the Kansas Department of Health and Environment (KDHE) and the Kansas State Veterinary Diagnostic Lab (KSVDL) for KSVDL personnel to use BSL-3 lab space to begin conducting SARS-CoV-2 screening to enhance KDHE's capacity.

Research Reawakening

As the State of Kansas began planning for a phased reopening of businesses temporarily shuttered by the stay-at-home order imposed at the start of the pandemic, K-State units did likewise. The Office of the Vice President for Research, in conjunction with the Associate Deans for Research of the larger, more research-active colleges, developed detailed plans for "reawakening" research, with a phased approach matching the University-wide plans and reflecting the State of Kansas timing.

The State reopening began in June 2020. In the first month, the so-called Phase 2, strict occupancy limitations and social distancing guidelines constrained research activities both in laboratories and in field settings. In addition, for the duration of the reawakening Phases 2 and 3, the latter of which did not end until the summer of 2021, particular research activities were not allowed, specifically:

- Adding new undergraduate researchers to lab-based studies; and
- Face-to-face human subjects research.

Needless to say, both of these strictures and other constraints negatively impacted some research studies.

Metrics Around COVID-19/ Pandemic Impacts

There are multiple ways to parse the impact upon research of the pandemic and research hibernation. One is to ask what benefits accrued. When federal funding became available in spring 2020 for research on the novel coronavirus, K-State started tagging proposals related in some way to the virus, its impacts on health and society, and on possible ways to ameliorate the latter. To date, K-State

has received over $21 million in funding, specifically for work on SARS-CoV-2—testing, disinfection, basic research, and countering economic impacts, exclusive of the CARES Act Higher Education Emergency Relief Fund funding to the University.

The impacts of the hibernation of most active research and subsequent slow resumption, coupled with continuing K-12 school closures, have yet to be fully analyzed at most institutions and nationally. There has been speculation that researcher productivity would be negatively impacted, particularly for researchers who were parents, and that women might disproportionately be affected (Collins, 2020). Subsequent analyses discussed these issues in more detail, including effects on underrepresented minority researchers and have suggested strategies for ameliorating the negative impacts (Carr et al, 2021). K-State has not yet done an in-depth study into these questions.

In terms of research productivity writ large, we have compared proposals and awards for the last five fiscal years broken out by quarter. Figure 1A shows that while FY 2021 (July 1, 2020-June 30, 2021) had a lower total dollar amount in proposed activities than FY 2020, which was a new high for K-State, most of the record-setting total for FY 2020 can be attributed to the first quarter. Furthermore, the last quarter of FY 2020, corresponding to the hibernation period, had a lot of proposal activity. Of course, proposal activity is largely dependent on what funding opportunities arise during each quarter/fiscal year, in addition to the time researchers spend on submitting proposals.

Figure 1B shows that both FY 2020 and FY 2021 easily eclipsed the prior years in terms of award dollars. Again,

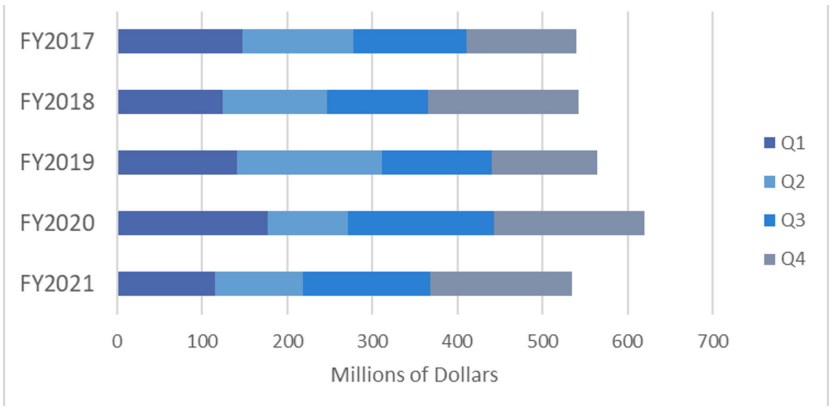


Figure 1A. Proposal activity in dollars for fiscal years 2017-2021.

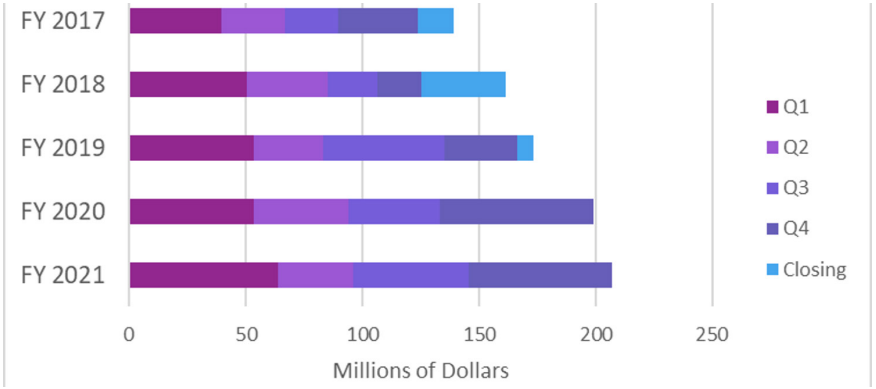


Figure 1B. Award activity in dollars for fiscal years 2017-2021.

this is partly dependent on the periodicity of funding opportunities and the renewal cycles for existing large program projects. Both FY 2020 and FY 2021 totals include the Higher Education Emergency Relief Fund awards that came in as sponsored projects to the university.

Where do we go from here?

As the nation moves in halting steps away from the COVID-19 pandemic, researchers and research administrators are looking to the future. Many of the recently released and forthcoming opportunities authorized under the American Recovery Plan seek to rebuild and strengthen the economy. This is coupled with an increasing trend of state and local governments looking to universities, particularly research universities, as engines of economic development.

K-State will continue to build on our traditional strength areas, particularly in the natural sciences, engineering, and agriculture; foster interdisciplinary work; and adhere to our land-grant mission to support communities and the state with innovations promoting economic prosperity. Our blueprint for the future in this area is articulated in our response to the 2020 strategic plan from the Kansas Board of Regents (KBOR), *Building a Future* (KBOR, 2020).

This document defines three so-called pillars:

1. Helping Kansas Families
2. Supporting Kansas Businesses
3. Advancing Kansas Economic Prosperity

Universities have historically worked to provide trained workers to fill jobs dictated by the economic conditions at the time. KBOR, with its articulation of Pillar 3, seeks to advance the *creation of jobs* and *direct investments* beyond state borders. Creating the jobs of the future will require:

- Alignment of education and local, state and federal government;
- Partnerships with private business, industry and investors;
- Actively working, engaging, and leveraging the attraction of investment capital in Kansas' core strength areas; and
- Infrastructure investments, including in people, process, information, and technology (e.g., broadband).

KBOR made Pillar 3 a charge for the six Kansas Regents universities, with the responsibility for Pillar 3 initiatives residing with the university CEOs, and they went further to identify the leads for Pillar 3 working groups at each university. K-State's Pillar 3 planning team was then-Vice President for Research Peter Dorhout, K-State Foundation CEO Greg Willems, and K-State Innovation Partners CEO Kent Glasscock. The charge from KBOR stressed that proposed programming and strategies must be focused on the two key metrics of jobs and investments.

K-State chose four focus areas for our Pillar 3 plan, reflecting our land-grant mission and the disciplinary areas in which we have primarily benefited from partnerships with the private sector:

1. Food and Agriculture Systems Innovation
    a. Will build on our historic strengths in advanced breeding techniques and integrated cropping systems.
2. Digital Agriculture and Advanced Analytics
    a. Will exploit existing computing capacity, work with artificial intelligence systems and precision agriculture.
    b. Will take advantage of the geographic one of a range of climatic zones across the state that mimic many of the significant agricultural regions globally.

3. Biosecurity and Biodefense
    a. Will leverage BSL-1 through BSL-4 assets on and adjacent to campus and our partnership with USDA facilities, including the National Bio- and Agro-Defense Facility.
4. K-State 105
    a. Will build on the statewide research and extension network and its presence in all 105 Kansas counties to create a statewide economic development network.

Food and Agriculture Systems Innovation

- *New scalable multi-disciplinary links to enable sustainable systems-level food and ag research.*
- *Potential innovations in alternative crop development, value-added opportunities, and ag tech innovation and applications.*

The Kansas Framework for Growth (KS Department of Commerce, 2021) focuses on five tradable industries. Kansas is twice as specialized as the national average in one of these industries: food and agriculture. The Framework for Growth specifically calls out leading higher education institutions specializing in food and agriculture to utilize extension systems and research facilities to make Kansas "a world-class home to research, development, and testing of new technologies in animal health, crop science, ag-tech and data analytics." This proposal directly responds to all four Kansas Framework for Growth strategic pillars (talent, innovation, community assets, and policy) and how the shared strategies are seeking value-added opportunities, ag tech innovation, sustainability initiatives, and the targeted support of producers.

The Food and Ag Systems focus area proposes a stakeholder-driven, systems-level strategy that includes a transdisciplinary team of researchers, as well as regular engagement with an advisory board to identify appropriate opportunities and venues. Partners across food and agriculture systems will include industries, producers, processors, regional foundations, commodity and trade organizations, as well as federal and state government. Consumers will be involved at both ends of the food production pathway.

The desired outcomes of these activities are:

1. Stimulation of economic growth and job creation;
2. Establishment of profitable, regenerative, and sustainable food and agriculture systems;
3. Fostering of disruptive technology and innovation; and
4. Improvement of Kansas community health through nutritional security.

Digital Agriculture and Advanced Analytics (DAAA)

- *Artificial intelligence for production agriculture.*
- *Scale-independent precision agriculture, current and emerging threats to crops and precision livestock production.*

This focus envisions the incorporation of existing K-State expertise in advanced breeding techniques and integrated cropping systems research to better attract opportunities and establish strategies that grow the capabilities and capacity needed to firmly establish K-State

as a global leader in DAAA. It draws on expertise from multiple K-State colleges to firmly establish K-State as a true "cyber-land grant" institution.

Kansas is uniquely positioned to serve as a DAAA development hub. The extreme variability of climatic and production conditions found in Kansas positions the state as an analog for a significant portion of U.S. and global dryland and irrigated agricultural regions (Figures 2A and 2B; images from Kottek et al., 2006).

K-State's distribution of regional research and extension centers (Figures 3A and 3B) span this climatic gradient, making it an ideal laboratory for developing DAAA in the most variable and challenging environments.

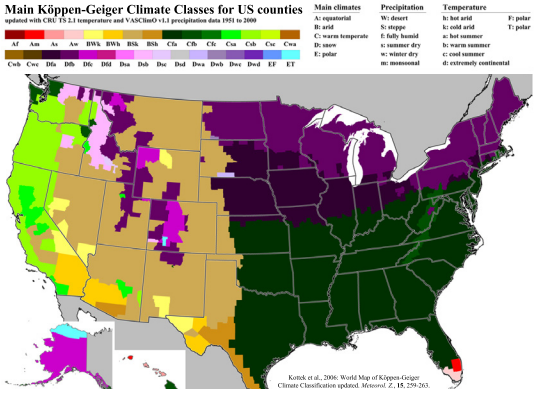


Figure 2A. Climatic zones of the US.

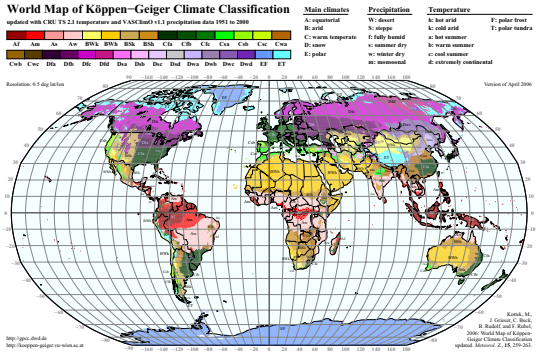


Figure 2B. Climatic zones of the world.

Additionally, K-State owns or leases nearly 30,000 acres of land dedicated to DAAA throughout the state, including the Lonsinger Sustainability Farm, to inform sustainable, resilient, climate-smart crop and livestock research and development.

Biosecurity and Biodefense

- *K-State will add a Biologics Development Module under BSL-3 containment to the BRI, enabling private sector vaccine/therapeutics manufacturers and their university researcher partners a pilot production facility.*

K-State has made significant investments in biosecurity and biodefense and is currently the only university in the world at which researchers have access to a full spectrum of BSL1-4 facilities lo-

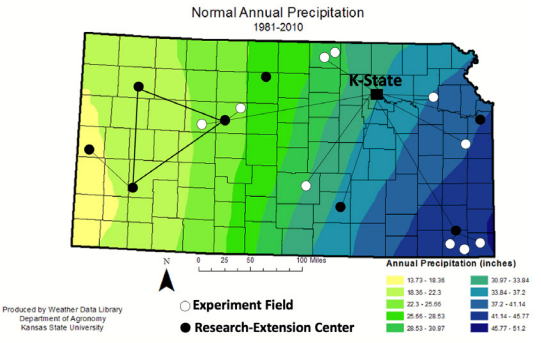


Figure 3A. Precipitation gradient across KS superimposed with locations of experiment fields and research-extension centers. Data from Weather Data Library, Department of Agronomy, Kansas State University.

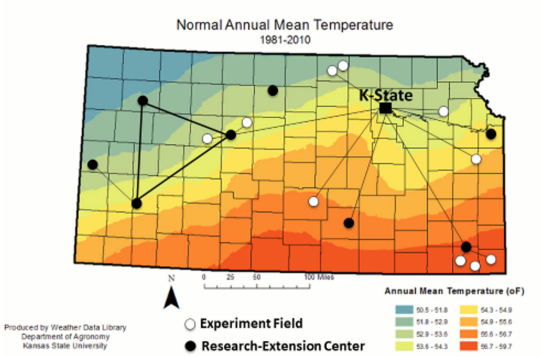


Figure 3B. Temperature gradient across KS superimposed with locations of experiment fields and research-extension centers. Data from Weather Data Library, Department of Agronomy, Kansas State University.

cated on or adjacent to campus. BSL1-3 spaces exist on the Manhattan campus, with most of the latter at the Biosecurity Research Institute (BRI). The BSL-4 USDA National Bio- and Agro-Defense Facility (NBAF) is located immediately adjacent to the BRI and has established a number of partnerships and cooperative agreements with K-State units and individual researchers.

While extensive, K-State's biocontainment capacity for intellectual discovery at these facilities is not sufficient to advance economic development. We propose to address this by adding a Biologics Development Module to the BRI. This BSL-3 facility strategy will increase capacity for commercialization and manufacturing to ensure technological advancements are utilized in practical application. This structure will streamline the discovery to commercialization process for industry partners by reducing the regulatory burden associated with conducting containment/non-containment and live animal/benchtop research at multiple institutions. The extensive talent and infrastructure in Manhattan will attract companies, entrepreneurs and venture capitalists to the region. New technology will be developed for economically important plant, animal, and zoonotic infectious diseases. No other university will have comparable assets.

During the COVID-19 pandemic K-State has been in a unique position to pivot research and contribute solutions for global human health using existing resources. The BRI was instrumental in securing for K-State $12 million in funded grants, as well as several licensing agreements related to COVID-19. The notable limitation was the capacity for commercialization at this facility. The proposed strategies will allow K-State to become the foremost U.S. resource to facilitate private-public collaboration for research on pathogens of worldwide significance. These assets will strengthen relationships with industry and increase access to export markets for food and agricultural products. K-State's collective expertise in vaccine development, regulatory affairs and flexible manufacturing capacity will not exist anywhere else in the world. A global reputation for success in discovery and commercialization will enhance our opportunities to attract corporate pharmaceutical partners, licensing agreements, and workforce talent.

K-State 105

K-State will augment its presence in 105 counties in Kansas, creating an "Every Town to Gown" initiative designed to deploy cutting-edge research and development, workforce development initiatives, and new practices that solve relevant problems, support community and economic development, and encourage connectivity between urban and rural areas. K-State will establish streamlined mechanisms for businesses and communities across the state to access our innovation, talent, and training through local liaisons and coordinated resources. This initiative will further our status as a leader in community vitality and focus on creating sustainable growth across the state.

With research centers, experiment fields, and extension services throughout the state, K-State's campus literally extends to every county in Kansas. While our statewide presence and network already attracts state, federal, and private funding, strategically leveraging this core capacity will attract additional investment and corporate partners seeking to build their workforce and advance the development of new innovations. From local rural communities to state-of-the-art laboratories, our network connects resources to regional needs and opportunities. K-State 105 promotes local collaboration and investments in the human, social, and financial capital of our Kansas communities.

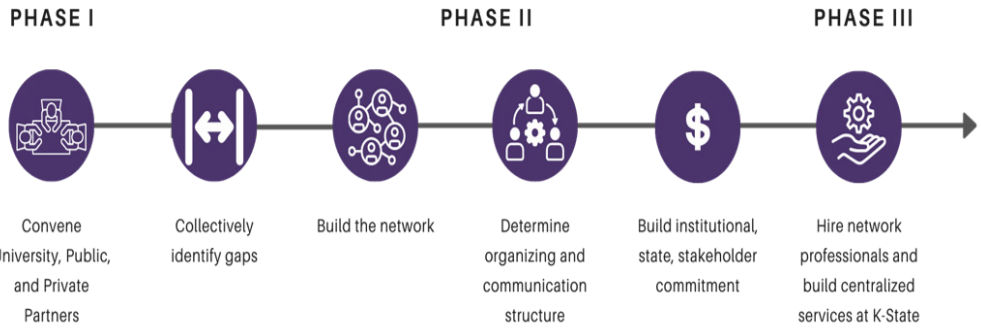
Our statewide research presence, combined with the climate and soil vari-

ability across the state, provides unique opportunities for agricultural research. K-State can be expected to achieve this aspirational goal because of our well-established network of highly respected Extension professionals throughout the state, as well as through partnerships with existing state and local economic development professionals.

Initial phases will utilize existing resources to convene stakeholders to better understand statewide needs and match relevant university resources to assist with targeted solutions. The goal of these efforts is to have our existing resources engage communities at a deeper level to identify challenges they are facing and bring them forward to determine if K-State resources can be used to assist in accomplishing their goals. Later phases will include adding dedicated liaisons and more effectively coordinated operational units to deploy needs-based solutions. As these phases are deployed, the university will examine existing engagement processes and alter them in ways that streamline the engagement pipeline.

In order for aggressive implementation to occur, the K-State 105 initiative will require external resources, particularly to fund the convening and coordination capacity needed to truly leverage K-State's existing presence in 105 counties and the centralized resources that can support statewide needs. In addition to investment from federal, state, local, private industry, and nonprofits, this initiative will require a commitment from communities and regions, as well as university stakeholders and partners. Public and private partners who will help execute the strategies, include, but are not limited to:

- Small Business Development Center (SBDC) - Coordinate small business and entrepreneur research and technical assistance needs with university.
- Kansas Department of Agriculture (KDA) - Coordinate the implementation of the Kansas Agriculture Growth Strategy.
- Kansas Department of Commerce - As the state's lead economic development agency, administer programs and services to support businesses, grow the economy, and improve quality of life across the state.
- NetWork Kansas - Leverage statewide network of non-profit business building resources to assist small businesses and entrepreneurs.
- Kansas Board of Regents (KBOR) - Coordinate on the implementation of strategic initiatives across the Pillar 3 Economic Prosperity focus of the KBOR strategic plan.
- Business Resources for Innovation and Exporting (BRITE) Center - Assist in matching regional needs with resources, including access to capital.
- Local Economic Development Partners - Partner with local county Extension to identify regional needs and opportunities related



to business recruitment, retention, and growth, as well as workforce development and community vitality needs.

Our Pillar 3 focus area development activities were built upon the process followed during our successful pursuit of the prestigious Association of Public and Land-grant Universities *Innovation & Economic Prosperity* designation process, which included input from over 250 faculty, staff, and external stakeholders. Furthermore, the Pillar 3 focus areas are aligned with goals laid out in the original K-State 2025 strategic plan (https://www.k-state.edu/2025/).

Summary

To quote from our Pillar 3 strategic plan document submitted to KBOR: "K-State's Pillar 3 plan creates an initiative that will become a part of the university's long-term strategic plan and will be aligned with other related initiatives to increase efficiencies and impact and avoid duplication. The initiative will be focused on issues of primary importance to state policymakers and citizens of the state, jobs and prosperity. This initiative will connect university efforts directly to the national and international marketplace where jobs and prosperity are a match between our capabilities and market needs at a scope and scale that has never happened before. The institution will naturally evolve in ways to take full advantage of the initiative, the global marketplace, and the issues of importance to Kansans. As with any other innovative advancement, K-State of the 21st century will evolve at much greater velocity than ever before."

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Exploring Differences in Androgen Deprivation Therapy Use for Prostate Cancer Between Black Men and White Men

Sally L. Maliski, PhD, RN, FAAN
Amy Garcia, DNP, FAAN
Ellen Harper, PhD, RN, FAAN
Francis Yang, PhD
University of Kansas School of Nursing

Androgen deprivation therapy (ADT) is the standard treatment for metastatic hormone responsive prostate cancer (CaP), and when surgery or radiation is not an option for localized CaP. ADT is increasingly recommended as an adjuvant treatment with radiation therapy[1] because of its survival benefit.[2] ADT has also been shown to benefit men with metastatic disease. It can delay the onset of symptoms such as pain and fracture from bone metastasis, urinary obstruction, and bowel obstructions.[3] ADT can be effective for two to three years in delaying the progression of CaP and its symptoms. Yet, it has been demonstrated that Black men are less likely to receive ADT compared to their White counterparts (OR=0.64).[4-6] In a previous study using SEER-Medicare linked data, among men with locoregional CaP, Black men were significantly less likely (24%) to receive ADT than other White men.[6] Furthermore, Cobran and colleagues (2018) found that Black men with metastatic CaP experienced significantly delayed receipt of ADT as compared to White men (172 days vs. 95 days, $p<0.05$).[7] Additionally, others using SEER-Medicare data found that Black men with metastatic CaP were less likely to receive ADT, and when they did receive it, the treatment was delayed compared to other men.[3,8] Despite the evidence supporting the benefit of ADT, in combination with radiation therapy, either adjuvantly or neoadjuvantly, to produce better outcomes,[9] Black men are less likely to receive ADT with radiation therapy. Findings from a population-based study of men with locally advanced CaP showed that, even though radiation therapy combined with ADT is better than either alone, only 8% of Black men received radiation therapy plus ADT compared to 84% of other men.[10] Therefore, the purpose of this convergent, mixed methods study is to explore provider and patient factors related to ADT receipt between Black and White men in a midwestern health system.

Specifically, we aim to:

1. Describe differences in ADT receipt between Black men and White men using the EPIC Clarity database, which includes clinical and demographic data by:
   a. Adjuvant use with radiation therapy;
   b. Timing to initiation of ADT with metastatic CaP; and
   c. Type of ADT utilized (surgical vs. medical).
2. Identify provider characteristics (e.g., specialty, years in practice, age, gender) and ADT utilization/recommendation patterns for Black men and White men.
3. Explore perceptions of and experiences with ADT among Black and White men using individual, semi-structured interviews.

From our analyses of these data we will create an initial explanatory framework of differences in the receipt of ADT

between Black men and White men, which will be the foundation for future testing and eventual development of practice guidelines and policy recommendations.

Background

Black men are diagnosed with more advanced and aggressive CaP at an earlier age than men of other ethnicities and are 44% to 75% more likely to develop metastases.[11,12] While overall mortality rates from CaP have declined, they have not declined as rapidly for Black men, and studies still indicate that Black men are more likely to receive inferior treatment.[11,13-16]

Factors influencing ADT decision-making that underlie treatment patterns are complex and include patient, provider, system, and socio-cultural factors, as well as social determinants of health (SDOH). Much of the literature on CaP patient decision-making is focused on screening and early-stage treatment (prostatectomy, radiation treatment, or active surveillance), and decision aids (DA),[17-23] while race/ethnicity's role in CaP decision-making has not been extensively explored. Some factors found to influence men's treatment decisions are treatment-related side effects, such as erectile dysfunction, urinary dysfunction, bowel dysfunction, quality of life (QOL), and, most strongly, physician recommendation.[5,17] A few studies have addressed race in treatment decision-making, primarily in screening decisions and DA for early-stage CaP.[24-27] One study was found to address patient perceptions toward recurrent CaP and ADT, but it only focused on outcomes of a DA, and did not address race/ethnicity.[25] Thus, there is a gap in the literature regarding the factors contributing to differences in ADT receipt between Black and White men.

In early-stage CaP treatment decision-making, the literature demonstrates that providers are influenced by grade, survival prediction, and patient financial and insurance statuses.[28,29] There is a growing body of research studying the effect of implicit bias on the provider's clinical decision-making, with providers having a White preference, regardless of the provider's specialty.[30-37] Most of the studies used the Implicit Bias Association Test (IAT) or vignette design to examine the influence of patient characteristics on treatment decisions. Another body of literature supports the practice of shared decision-making.[38,39] While patient characteristics related to the desire for shared decision-making were explored, provider characteristics related to approach to and acceptance of shared decision-making was not. Provider characteristics were addressed to some extent in the literature on burnout, depression, and physician engagement.[40-45] One study, conducted in Ireland, found that as the provider age increased and socio-economic status of the patients decreased, quality of care decreased.[46] Thus, provider characteristics can play an important and sometimes unrecognized role in treatment recommendations, including those related to ADT.

Numerous studies investigating ADT have not identified race in their samples, and if they did, race was not included in analyses.[47-49] While some documentation of differences in ADT receipt by Black men compared to White men exists as noted above, there is a dearth of literature exploring factors that may explain these differences, specific to ADT, from either the provider characteristics or the patient perspectives. This study will lay the foundation for future interventions to address disparities in ADT receipt by Black men.

We will use the National Institute on Minority Health and Health Disparities

Table 1. Adapted NIMHD Research Framework for ADT Utilization

	Individual	Interpersonal	Community	Social
Biologic	CaP stage Comorbidities Age (Aim 2,3)			
Behavioral	Men's perceptions Information-seeking Care-seeking (Aim 3)			
Sociocultural Environment	Race Income/occupation Education (Aim 2.3)	Partnership status (Aim 3)	Men's experiences in healthcare systems (Aim 3)	
Healthcare System	Insurance coverage (Aim 2,3) Barriers (Aim 3)	Patient-provider relationship (Aim 3) Provider characteristics (Aim 2,3) ADT prescription patterns (Aim 1,2)		Differences in ADT receipt by Black men (Aim 1)

Explanatory Framework of Differences in ADT Receipt for Black Men

(NIMHD) Research Framework, focusing on the individual and interpersonal levels of influence within the behavioral, sociocultural and healthcare system domains of health. Outcomes explored in this study include individual health and population health, with a description of factors that influence ADT utilization and decision-making for Black men who would benefit from ADT. We hypothesize that ADT utilization and decision-making will be different for Black men relative to White men. Table 1 illustrates the Domains and Levels to be explored in this study.

Methods and Design

We are using a convergent, mixed methods design to describe factors that contribute to differences in ADT receipt between Black men and White men.

For Aim 1, we are describing and comparing ADT utilization between Black men and White men. Receipt patterns are being explored for adjuvant use of ADT with radiation therapy, those with a diagnosis of hormone-responsive CaP, and by type of ADT used. Type may be surgical (orchiectomy) or medical. While surgical ADT is no longer in common use, when it is used, there is a higher representation of underserved, minority men.

In Aim 2, we are exploring the characteristics of providers who prescribe ADT in an effort to describe patterns of ADT receipt by patient sociodemographics (e.g., age, insurance status, zip code), to uncover factors which may influence provider decision-making.

For Aim 3, we will examine Black and White men's perceptions of and experiences with ADT, including the men's interactions with providers about ADT. We will explore men's beliefs, attitudes, information received, and treatment options presented to them.

Sample and Setting

Aim 1: The University of Kansas Medical Center (KUMC) is associated with The University of Kansas Health System (TUKHS). TUKHS utilizes the Epic electronic health record (EHR) system, Epic Systems, Verona, WI. The EHR has been branded as "O2" which stands for Optimal Outcomes. Epic Clarity is a large relational database that receives a subset of data from O2 on a nightly basis and is typically used for operational and research reporting purposes. Inquiry

within the Epic Clarity database identified approximately 14,495 men with CaP who were treated with ADT or who were candidates for ADT between 2010 and 2020.

Extracts will include candidates for ADT as defined as those with a diagnosis of metastatic CaP (APR-DRG, ICD-9, ICD-10) and the patient demographics (age, gender, race, ethnicity, date of diagnosis) will be collected. Among those men, we will identify those who had any combination of adjuvant ADT treatments, including those with radiation (using CPT codes), medical hormone-responsive ADT (using specific medications), and those who had surgical ADT (using CPT codes). Clarity captures the "authorizing" provider with a date/time stamp for every diagnosis documented and orders for ADT treatments. Provider demographics such as name and the National Provider Identifier (NPI) from the Clarity data will be the common link to additional data sources.

Aim 2: Using the provider name and NPI, we will extract provider demographics obtained from the Human Resource systems (Kronos and Workday) and/or the National Plan & Provider Enumeration System (NPPES). The integrated data will be used to compare and contrast patterns in treatment regimens. ADT is prescribed by oncologists, radiation oncologists, and urologists at the TUKHS. There are currently 51 oncologists, 16 radiation oncologists, and 15 urologists practicing.

ADT prescribing patterns will be obtained from the Clarity data and matched to provider characteristics obtained from the Kronos, Workday, and/or the NPPES dataset. The unique NPI is the key to integrating the datasets. The integration of various data sources enables researchers to look at the data in new ways that are not available when viewing data one source at a time.

Aim 3: We will recruit a stratified purposive sample of Black and White men from those identified as eligible for ADT in Aim 1. Using a stratified sampling approach will facilitate comparisons based on self-identified race. Eligibility for inclusion in the interviews: 1. Aged 45 or older, 2. Self-identified as non-Hispanic Black or White, and 3. Willing and able to articulate perceptions and experiences about ADT. We will purposively select men who received ADT and men who were candidates for ADT (as defined above) but did not receive ADT. We will recruit and collect data until we reach data saturation to allow for comparisons between groups. However, based on qualitative literature,[50] data saturation can be reached with 15-30 participants, so we plan to include a sample of 30 men: 15 men who identify as Black and 15 men who identify as White.

The Patient Identification via Pioneers Registry is a registry of patients in the community who are interested in research; the registry will be used to invite people to participate. We will work with established community contacts in the Black community and a prostate cancer support group to create a Patient Advisory Board (PAB). The PAB will provide advisement on best methods for study recruitment and enrollment, the development of interview guides, and the interpretation of qualitative data. Virtual meetings will be scheduled quarterly, with communications with the study team in between as needed. Semi-structured interviews will be conducted using a HIPAA-compliant virtual platform.

Data Collection Schedule and Procedures

The data collection workflow and data sources are outlined in Figure 1.

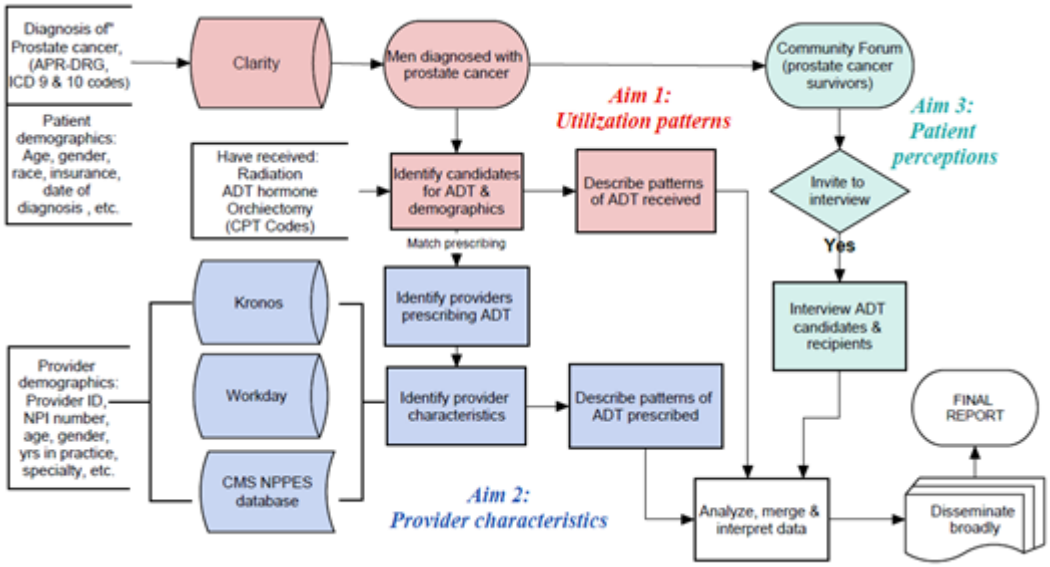

Figure 1. Data collection workflow.

Aim 1: First, data of men who were candidates for ADT will be extracted from the Clarity database. Next, they will be grouped by those who did and did not receive ADT by race/ethnicity. Those who received ADT will be grouped by type of ADT (surgical vs. medical), CaP type (adjuvant or metastatic recurrent disease), and by race/ethnicity. Next, for the men with metastatic disease, we will identify the time from receipt of metastatic diagnosis to initiation of ADT. Men on ADT will be identified using APR-DRG, ICD-10 designation for CaP. A thorough and complete search for surgical and medical ADT will be completed using the following search terms: orchiectomy (surgical ADT); luteinizing hormone-releasing hormone (LHRH) agonists, which include Leuprolide (Lupron, Eligard), Triptorelin (Trelstar), Goserelin (Zoladex), Histrelin (Vantas); LHRH antagonists, which include Degarelix (Firmagon); and anti-androgen therapy, which includes Flutamide (Eulexin), Bicalutamide (Casodex), Nilutamide (Nilandron), Abiraterone (Zytiga), and Ketoconazole (Nizoral). Anti-androgens, which can be used for castrate-resistant CaP (for those who are no longer responding to other forms of hormone therapy), include Enzalutamide (Xtandi), Darolutamide (Nubeqa), and Apalutamide (Erleada).

Aim 2: To describe provider characteristics and prescribing patterns, we will manually retrieve NPPES data, using the NPI as key. This will allow us to investigate whether clusters of specific provider characteristics correspond with ADT prescribing patterns for Black men compared with White men. Provider characteristics will include age, time in practice, medical education in the U.S. or international, certification, location (urban, rural), and specialty.

Aim 3: Before recruiting for the individual interviews, we will establish the PAB, which will be comprised of Black and White CaP survivors. We will work with an African American Cancer Community Advisory Board, co-led by Mr. Broderick Crawford and Dr. Peltzer, and the Prostate Cancer Network, led by Mr. Steve Hernsten, to identify and invite six men to be a part of the PAB. The PAB will be convened to provide insights

into perceptions of men relative to CaP and ADT. The PAB will help develop the semi-structured interview guide to ensure the questions are culturally appropriate and sensitive for eliciting men's understanding and perceptions of CaP and ADT, factors that influenced their receipt of ADT, sources of information, and their perceptions of their interactions with their provider regarding ADT.

The PAB will also assist with recruitment efforts, creating recruitment materials and identifying the best approaches (mailings, social media, telephone calls) for inviting potential participants and disseminating study information through their social networks. The recruitment materials will also be shared with clinic staff to disseminate and by study staff via email, telephone, or mail. Only men who have given permission to be contacted for research in the EHR will be contacted directly by study staff. The information will include the contact information of the study coordinator to further information and interest in the study. The study coordinator will respond to contacts and call to provide further information, ascertain eligibility, and invite participation.

IRB-approved online consent will be obtained and an interview appointment made. Interviews will be conducted by videoconference, if possible, and by phone, if videoconference is not available. Videoconference is preferable because visual cues, such as facial expression, are visible. However, our previous work has demonstrated that rich data can be obtained by phone interviews with careful attention to voice tone, cadence, and background noise. Interviews are expected to last 45-60 minutes and will be audio recorded. The audio recordings will be transcribed verbatim in preparation for data analysis. Participants will receive $50 compensation for their time.

The interviews will be conducted by a member of the research team who will be trained in qualitative interview techniques by the PI (Maliski) and Co-I (Peltzer). Prior to beginning data collection, the interviewer(s) will conduct two simulated interviews with Dr. Maliski or Peltzer, who will provide feedback on the technique. The interviews will begin with an overview of the study, including the purpose and a reminder that participation is voluntary, confidentiality will be maintained, and if there are any questions that are uncomfortable, the participant does not have to answer. The interviewer will ask for the study participant to share a little bit about his general health, CaP history, and other comorbidities before transitioning to questions about ADT. Following the completion of the interview, sociodemographic data, including age, self-reported race, insurance status, income range, employment, partnership status, and education, will be collected.

Data Analysis, Merging, and Interpretation

The culmination of the analyses will be an integration of the aims to produce an explanatory description of ADT utilization disparities and associated factors.

Aim 1: Length of time from diagnosis of metastatic CaP to initiation of ADT for each group (Black vs. White) will be compared, using the Kaplan-Meier estimator, represented through the Kaplan-Meier curve to show the probability of treatment from time zero diagnosis over five-year intervals. The test for proportional assumptions, using the scaled Schoenfeld residuals and Kaplan-Meier curves, will be satisfied before proceeding to the Cox Proportional Hazards Regression Model. A Cox Proportional Hazards Regression Model will be used to examine if there are statistically significant differences in surgical and medical ADT and receipt

of adjuvant ADT with radiation therapy between Black men and White men, and types and numbers of comorbidities experienced before and after treatment between groups over time, respectively.

Aim 2: To identify the profiles of provider characteristics [age, time in practice, certification, location (urban, rural), medical education (U.S. or international), specialty, and ADT prescribing patterns], a latent class analysis will be used to identify the best fitting number and type of clusters within the Clarity dataset. Latent class analysis is based on posterior probabilities estimated through bootstrapping the data over multiple iterations to identify the patterns of characteristics that best describe data that may not emerge through traditional statistical models. The goodness-of-fit statistics are as follows: Akaike Information Criterion (AIC), Log-likelihood (LL), Bayesian Information Criterion (BIC), and sample size-adjusted BIC (SABIC).[51] In Mplus version 8.39[52] software, bootstrap likelihood ratio test (LRT) and Vuong-Lo-Mendell-Rubin LRT to determine the best-fitting model between two sequential LCA estimated models, with a higher p-value favoring the prior LCA model.

Aim 3: Data will be analyzed concurrently with data collection using qualitative content analysis.[53] This will allow emergent themes to shape subsequent data collection to more fully describe categories. Data will be entered into DeDoose for data management. Analyses will be conducted by the PI (Maliski) and co-I (Peltzer). Both will independently read the initial five transcripts and code using segment-by-segment coding to capture the main thought in each segment. They will then cluster codes into broader categories after which the analysts will meet to develop consensus on the codes and categories. Using those categories, the analysts will code transcripts as the data are collected. New codes or categories will be added as they emerge. Analysts will meet to review data and categories, returning to the data to validate categories. The PAB will be consulted regarding the relevance of the categories. Finally, from the categories, analysts will develop themes that represent the data and describe men's perceptions of and experience with ADT and interactions with providers.

To ensure rigor, the research team will maintain a coding manual. Drs. Maliski and Peltzer will create, maintain, update, and revise the list of codes. Drs. Maliski and Peltzer will maintain at least 80% interpretive convergence.[54] The research team will also maintain analytic memos to document their coding processes, choices of codes, and the emergent categories, themes, and patterns.[54] The analytic memos will also be used to reflect on and document any problems that may transpire with the study and to assist with the final report for the study. The analytic memos, meeting minutes, and codebook will be used as the audit trail to ensure credibility of the study. The analysts will also complete member checking with a subsample of participants and provide the emerging themes to the PAB as an additional method of credibility and confirmability. We will carefully evaluate the emerging themes for differences between Black and White men regarding their perceptions and experiences.

Merging of Data: After statistical analysis of quantitative data and content analysis of interviews, the data will be merged for analysis. We will examine the textual data from the interviews and compare to ADT receipt patterns and to the provider characteristics and prescribing patterns. We will also assess the fit

of integration of the data[55] to evaluate if there is confirmation of or discordance between the men's perceptions and experiences with differences of ADT receipt patterns. If there is confirmation, the integrated model will provide a comprehensive description of factors related to differences in ADT receipt between Black men and White men.

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Lessons from the Department of Energy's Pandemic Response for Multidisciplinary Research

Julienne M. Krennrich
Director, Innovation Partnerships
jmkrenn@ameslab.gov
https://orcid.org/0000-0002-9683-838X
James R. Morris, Ames Laboratory
https://orcid.org/0000-0002-8464-9047

One of the hallmarks of science in the COVID-19 era is the remarkable advances that were made scientifically to address the pandemic. The rapid genomic analyses of the SARS-Cov-2 virus (and subsequent rapid sharing), the development and roll-out of vaccines, and other advances demonstrate both the ability to rapidly address new challenges and the ability to leverage strong research directions that have been in development for decades. However, the challenges were not simply in the areas of biology and medicine and are ongoing on multiple frontiers. From the experience of U.S. Department of Energy (DOE) labs, we see lessons to be learned in driving multi-institution, multidisciplinary research efforts that address significant challenges. While they were not set up specifically to address challenges such as this pandemic, their structure, organization, capabilities, and mission allowed them to pivot, dedicate significant resources, and rapidly form coherent research efforts across disciplines, capabilities, and institutions, to initiate and accomplish significant results in short times. The present paper describes the view from one of these laboratories, with the perspective of what may be learned toward organizing effective, larger research efforts.

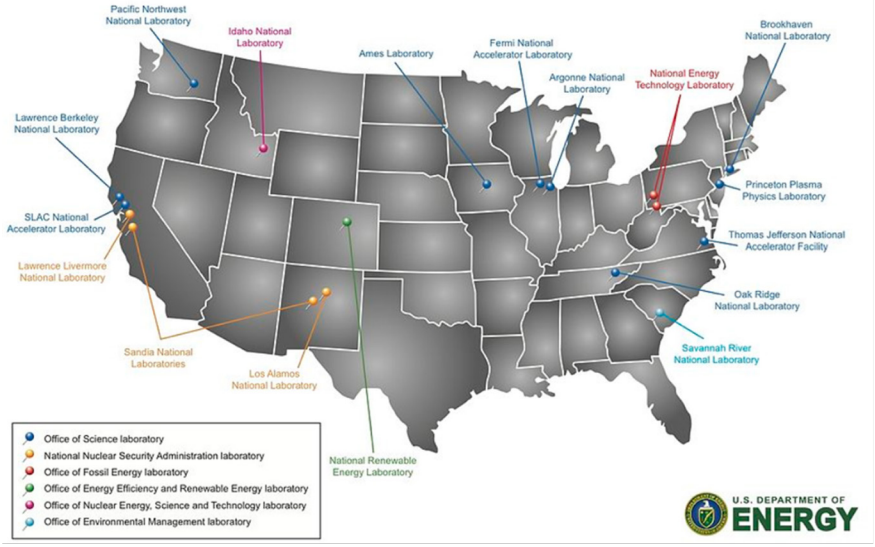
About Department of Energy Laboratories and Ames Laboratory

Ames Laboratory (Ames) is one of 17 national laboratories owned by DOE (see Fig. 1), and one of 10 operated by the DOE Office of Science.

The laboratory is operated by the Iowa State University of Science and Technology (ISU) via a Management and Operating Contract (M&O). This type of government contract is well-suited to managing risky work, such as research and development. This scenario is maximally beneficial for both Ames and ISU, enabling easy collaboration between ISU faculty and students and Ames scientists. Additionally, Ames benefits operationally from access to campus services and collaboration on emergency response and protective services.

One defining characteristic of the DOE Laboratories is their mission to lead large research and development efforts that require scale and provide user facilities to the scientific community. By combining state-of-the-art facilities with larger research programs, often spanning multiple institutions, including other DOE labs, universities, and industry, the Department of Energy tackles important scientific and technological challenges. For example, among a number of other projects, Ames leads the Critical Materials Institute[1] (an Energy Innovation Hub spanning four DOE labs, 13 universities, and many industries), two Energy Frontier Research Centers (EFRC),[2] and is a thrust leader for the Exascale Computing Project.[3] These efforts tackle significant basic, applied, and computational challenges within the physical sciences and are coordinated across multiple laboratories. Much of Ames' funding comes from the Office of Science's Basic Energy Sciences (BES) program, which is one of the largest sponsors of research in the physi-

Figure 1: A map of the U.S. Department of Energy Laboratories.



cal sciences and operates significant programs and facilities supporting the DOE mission. BES has had a significant impact since its inception.[4]

Response to COVID-19 Global Pandemic

When COVID-19 became a global pandemic in spring 2020, one of the big research challenges was coordinating across federal agencies to effectively address myriad response-related challenges. The U.S. Department of Health and Human Services and the National Institute of Allergy and Infectious Diseases were the epicenter of the disease expertise itself. The Federal Emergency Management Agency had been doing epidemic modeling before, but suddenly this was needed on a massive scale. One issue raised was how to combine epidemiological modeling with human behaviors and economic modeling. We knew that opening up businesses and schools would increase infection rates, but by how much? This more comprehensive modeling could really drive *local* policy on business/school opening, since different conditions and behaviors were highly dependent on local conditions.

There were also medical equipment supply chain issues. For example, where were the resources (masks, gloves, ventilators, tests) compared to where the needs were (which changed rapidly week to week, with little data on local resources)? At one point, every mechanical engineering department in the nation was suddenly designing ventilators; but how does one quickly sort through those to prioritize the testing needed for formal approval? Adding to the foray was the CARES Act[5] pushing research dollars to tackle these challenges with very short turnarounds for impactful deliverables.

In response, DOE created the National Virtual Biotechnology Laboratory (NVBL).[6] The NVBL could be set up rapidly due to coordination between the labs, their existing collaborations and complementary strengths, and culture of collaborative, multi-institutional collaboration. The DOE's Office of Science leadership quickly established the framework for how the NVBL would operate. The NVBL was led by two co-chairs who provided oversight and organization of a central committee with representation from all 17 laboratories. This committee organized the research priorities into top-level challenges. Then, through their representatives, each lab had an opportunity to propose what they could contrib-

ute to each challenge topic. The responses captured not only their capabilities and expertise, but also their ability to *leverage existing partnerships*. This accelerated the transition of the research into practice. The NVBL committee then collaboratively assembled these complementary "work statements" into projects under each topic area. Every project involved multiple laboratories and was selected according to the potential impact, the ability to coordinate while maintaining separate directions from other agencies.

The Ames Laboratory's role in the *Viral Fate & Transport*[7] project is instructive as an example. Ames has significant expertise in the physics and chemistry of alloys and metal oxides. The ability to tap into ISU's expertise and its BSL3 facility was an additional asset we could contribute that helped speed up measurements on an actual virus. The Ames-ISU partnership, in conjunction with Sandia National Laboratories, led to the discovery of a new approach to designing antiviral materials with a low toxicity to humans. Similarly, Ames was able to tap the deep expertise of an Ames/ISU joint faculty member to tackle the need for rapid onsite testing for virus presence as part of the COVID-19 Testing R&D.[8]

A key attribute that made the NVBL a success was the fact that the laboratories specialize in mission-oriented research that is responsive to dynamic priorities. They also specialize in tackling problems that require scale: research that takes advantage of numerous collaborative scientists working together with unique facilities (often larger-scale user facilities). Researchers in the laboratories are accustomed to working in multi-institutional teams combining multiple disciplines, as well as with university and industry partners, to identify and accomplish shared goals and challenges. Additionally, due to the M&O model, DOE could quickly disseminate funds to the labs. Although the NVBL framework was the first of its kind, and undertaken in a "maximum telework" environment, it turned out to be relatively easy to stand up, due to the existing research culture.

The DOE utilized its expertise and multiple strengths to address the pandemic response, complementing and supporting other national agencies. The NVBL addressed medical equipment supply shortages, discovered potential drugs to fight the virus, developed and verified COVID-19 testing methods, modeled disease spread and impact across the nation, and worked to understand virus transport in buildings and the environment. National laboratory resources leveraged for this effort included a suite of world-leading user facilities broadly available to the research community, such as light and neutron sources, nanoscale science research centers, genomic sequencing and biocharacterization facilities, and high-performance computing facilities.

Legacy of the NVBL: How will it shape the future?

The pandemic response demonstrated DOE's ability to formulate "rapid response" groups of scientists that could devote significant resources and expertise to a mission-oriented (not academic-oriented) issue. Publications came but weren't the goal. These teams were able to demonstrate significant impact within a matter of months. For example, "within just a few months, NVBL teams produced innovations in materials and advanced manufacturing that mitigated shortages in test kits and personal protective equipment, creating nearly 1,000 new jobs."[9] There has been ongoing discussion within DOE about creating a "Scientist Reserve Corps" that could mimic the NVBL type of response in preparation for future crises.

Within the context of climate change and the need to transition to a clean energy economy, the quick progress that has been made by the NVBL in transitioning R&D to commercial sector use really stands out as a possible model

moving forward. We believe we will see more efforts like these in other mission areas. For example, DOE is now defining Energy Earthshots, such as the one on hydrogen.[10] This is being coordinated by Science and Energy Tech Teams that cross DOE offices. DOE is also running more prize competitions. These represent areas where, with concentrated effort and resources, the research community really can make a difference in a short amount of time.

National challenges are inherently multidisciplinary, and rapid change requires more than technical solutions. The COVID-19 pandemic has demonstrated the importance of issues beyond science, such as scale up, supply chains, manufacturing (masks, tests), human behavior (willingness to wear personal protective equipment, isolate), policy (school, business shutdowns), and economics (business reopening).

In order to have a holistic response, the science had to be combined with all of the above to be successful. The key point is that *the challenge drives the collaboration across fields.* Articulating key issues carefully can be used to drive multi-institution/multidisciplinary collaborations.

Lessons for Multi-institution and Multidisciplinary Research

As we move into the future, we will confront Grand Challenges like CO_2 reduction; electric and autonomous transport; data, AI and health care; and place-based issues of energy and water. We should expect to see an increased need for collaboration across not just disciplines and institutions but also technology scales, such as deep expertise in basic science, engineering, technology demonstration, technology transfer/partnerships and deployment. The DOE Labs are well positioned to work with our university and industry partners to tackle these challenges.

More broadly, we point out that there is a broader lesson for successful projects that span multiple disciplines and multiple institutions. Such interactions often struggle due to narrower interests of a particular research group, institution, or discipline. NVBL had success not by addressing (only) individual groups, but rather by identifying a few, well-articulated directions, with clear expectations for rapid progress and for collaborative work, and guiding the research along those directions. Having a clear mission that is compelling, important, and wholly bought into by all researchers is crucial. Prioritizing cross-disciplinary and/or cross-institution efforts clearly also plays a role in forming such collaborative groups.

As an example of an important issue that undoubtedly spans multiple disciplines, from fundamental sciences to engineering to social sciences, consider the needs required to efficiently provide clean water across society. The issues are both *local* (what are local sources and conditions of water, what are local facilities or industries that require water, or that affect clean water supply) and *non-local* (local conditions are often strongly affected by what happens elsewhere; a community often will be strongly affected by what happens upstream). Increasing clean water supply may require more efficient approaches to remove contaminants, more efficient energy production (requiring less water resources), and new approaches to reduce sources of contamination (affecting industry and agriculture). Economic, infrastructure, and human behavior all directly impact options. While there are myriad research programs in each of these areas, we see potential for impactful research that combines multiple aspects, providing important demonstrations of the interplay and competition between these different areas.

Researchers require some independence and need to be able to bring forth ideas and act upon them, while balancing the importance of achieving the mission. The key motivating challenges of the research—rather than the individual disci-

plines that may address them—are more likely to get researchers to work together than "blank slate" approaches to teaming. Focusing and refining (as needed) these challenges are more likely to create and maintain cross-disciplinary research. We also posit that this is key to *impactful* research: having multiple constituencies agreeing on important goals often produces research unique to the collaboration, with impacts that are easier to articulate due to the clear goals. Such collaborations are often hard to maintain, but good leaders recognize how the pieces serve a larger whole, and serve to both allow individual researchers some freedom to explore and to innovate, while keeping projects from devolving into handfuls of more parochial interests. To confront and respond to our pressing national challenges, the research culture needs to be collaborative, innovative, and nimble—rather than focused purely on small group/small project visions. The Department of Energy, and its National Laboratory system, has long sought to nurture this type of culture, balancing mission-focused work with core expertise and capabilities.

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Effects of the COVID-19 Pandemic and How We Adapted at the University of Missouri

Richard J. Barohn, MD
University of Missouri School of Medicine
Executive Vice Chancellor for Health Affairs
Executive Director, NextGen Precision Health initiative

I joined the University of Missouri (MU) in May 2020, during the early phases of the COVID-19 pandemic. My leadership administrative roles at MU are in the School of Medicine, MU Health Care, and in the NextGen Precision Health initiative. My role as the Executive Vice Chancellor of Health Affairs at the University of Missouri allows me to develop and implement a comprehensive strategy that affirms MU Health Care as a nationally recognized leader in patient care and to continue the MU School of Medicine's legacy of education and scholarly excellence.

How We Adapted to COVID-19 on a Multi-Center Clinical Trial

As a clinician researcher, I moved an investigator-initiated, federally funded grant to MU from the University of Kansas and remain a primary investigator. The study, "The ALS Memantine Trial Study (TAME)",[1] is a phase II study of the drug memantine for patients with amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease. It is an R01 funded study by FDA Office of Orphan Products Development. TAME is a multi-center, clinical trial of a drug that is currently FDA approved for the treatment of dementia in Alzheimer's disease. Our research team speculated that the drug may also be effective for ALS. As a phase II trial, our main aims were to establish that the drug is safe in high doses among ALS patients and to explore the effect of the drug on blood biomarkers for ALS. We were also trying to detect if the drug could slow the progression of ALS or cause an improvement of the neuropsychiatric symptoms involving cognition changes that are characteristic of ALS. This was not meant to be an efficacy study. The goal was to enroll 90 patients with ALS at 13 centers around the country (Table 1). The trial is a randomized control trial with a 2:1 randomization so that 60 patients would get the active drug and 30 would receive the placebo.

The COVID-19 pandemic had a significant impact on our approach and required changes to how we operationalized this study. On March 18, 2020, in the early phase of the COVID-19 pandemic, all academic health centers around the country announced that protocols involving research patients enrolled in trials

Table 1. TAME Site Table

Site #	Name
1	University of Kansas Medical Center
2	Nerve & Muscle Center of Texas
3	University of Missouri
4	University of Washington
5	University of Kentucky
6	UC - Irvine
7	HonorHealth
8	University of Kansas - Wichita
9	Cox Health - Springfield
10	University of Florida
11	Penn State Hershey Medical Center
12	Austin Neuromuscular Center
13	Providence Neurological

must be suspended because outpatient operations were shutting down. How did we adapt?

We immediately met with the study's steering committee, investigators, and coordinators at each study site to determine their ability to continue work on the project. We discovered that all sites were affected in somewhat different ways depending on the local policies at each university, but all had to suspend seeing ALS patients for research visits. We had to come up with an adapted protocol so that we could enroll new patients and continue seeing enrolled patients remotely using phone calls and video visits. We created an alternate set of inclusion and exclusion criteria that allowed for the participant to be enrolled partially or completely remotely. We used recently collected clinical data from the previous clinic visit to capture items that were needed for clinical enrollment, such as physical examination and vital capacity. We sent the modified protocol to the IRB at KU Medical Center. Because this was a federally funded multi-center trial, we were operating under the new rules that mandate the use of a central IRB. This turned out to be an advantage in this situation. Once the KU Medical Center IRB approved the modified protocol, we were able to quickly get the protocol approved through an administrative approach at all the other sites, which did not require additional IRB approval at those sites. Simultaneously, we sent an updated protocol to the FDA funding agency and FDA regulatory agency. We established a mechanism to send patients their study drug or placebo drug directly to their homes. Research coordinators provided monthly phone calls or video visits with patients and their families. We were able to maintain the collection of study data, such as patient ALS functional rating scale, adverse events, and medication counts remotely.

Figure 1 shows our study enrollment from the beginning of the study in November 2018 to the end of enrollment in September 2020. Amazingly, due to the changes we made in the protocol and to a commitment by the investigators, coordinators, and patients that we would not slow the study because of the COVID-19 pandemic, we actually *increased* the pace of study enrollment in the closing five

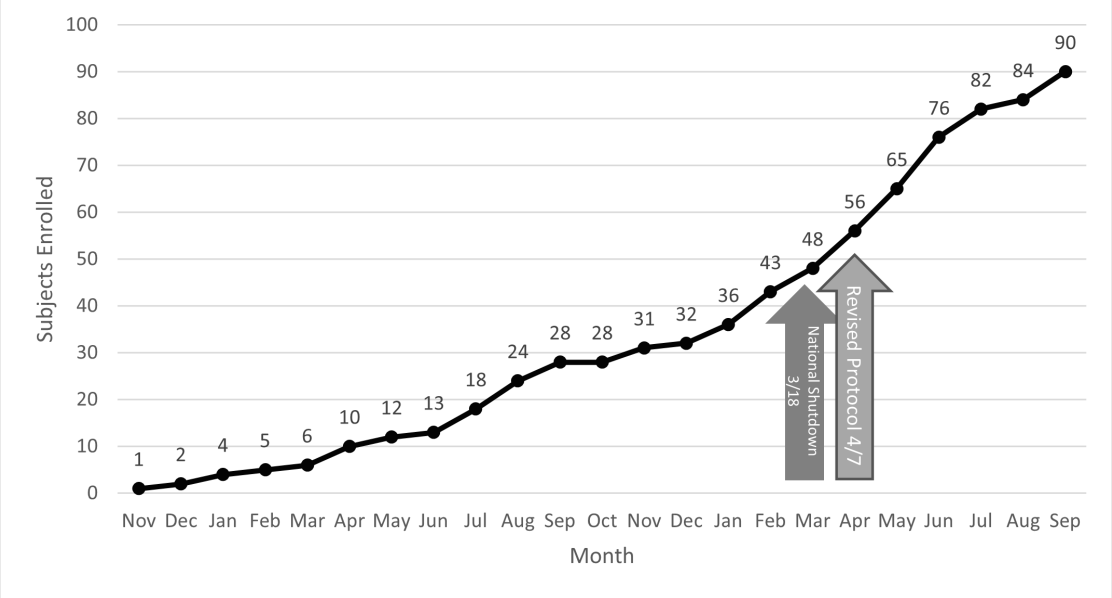

Figure 1. The number of subjects enrolled in TAME study from November 2018 through September 2020.

months of the study. Prior to using the new protocol, we enrolled 56 patients from November 2018 to April 2020; from April 2020 to September 2020, we enrolled 34 patients. We learned several lessons from this experience. We were quickly able to adapt the protocol, get buy-in from our investigators, get timely administrative review, and stay on target for completing enrollment. We found that using the central IRB mechanism with administrative approvals by each local IRB worked very well in making quick changes to the protocol that could be adopted at all sites. There is no doubt that many of the lessons learned under pressure from the COVID-19 pandemic will be useful in designing and conducting future clinical trials, irrespective of the pandemic situation.

Global Impact of the COVID-19 Pandemic on MU Research

Despite this positive outcome regarding the TAME study, overall research activity drastically decreased in 2020. Essentially, all laboratory studies were put on hold. By May 20, 2020, the University of Missouri began slowly initiating a research restart plan called "Show Me Renewal," and we began re-opening some laboratories and outpatient clinical research operations.

Because of COVID-19, MU investigators were able to become involved in nine COVID-19 clinical trials. In addition, our investigators were involved in 45 additional COVID-19-based research studies that included natural history studies, laboratory-tested studies, and non-trial clinical protocols. One of the problems we encountered with the drugs for the COVID-19 clinical trials was, at the time, not having enough COVID-19 patients hospitalized at MU Health Care to successfully recruit in each trial, particularly during the early phases of the pandemic. That did change in the fall and winter months of 2020 when our COVID-19 patient numbers increased and our maximum number of patients in the hospital was just under 100 during our highest daily census.

Another dimension of the COVID-19 pandemic has been its impact on finance. We saw an impact on our research expenditures during fiscal year (FY) 2021. From

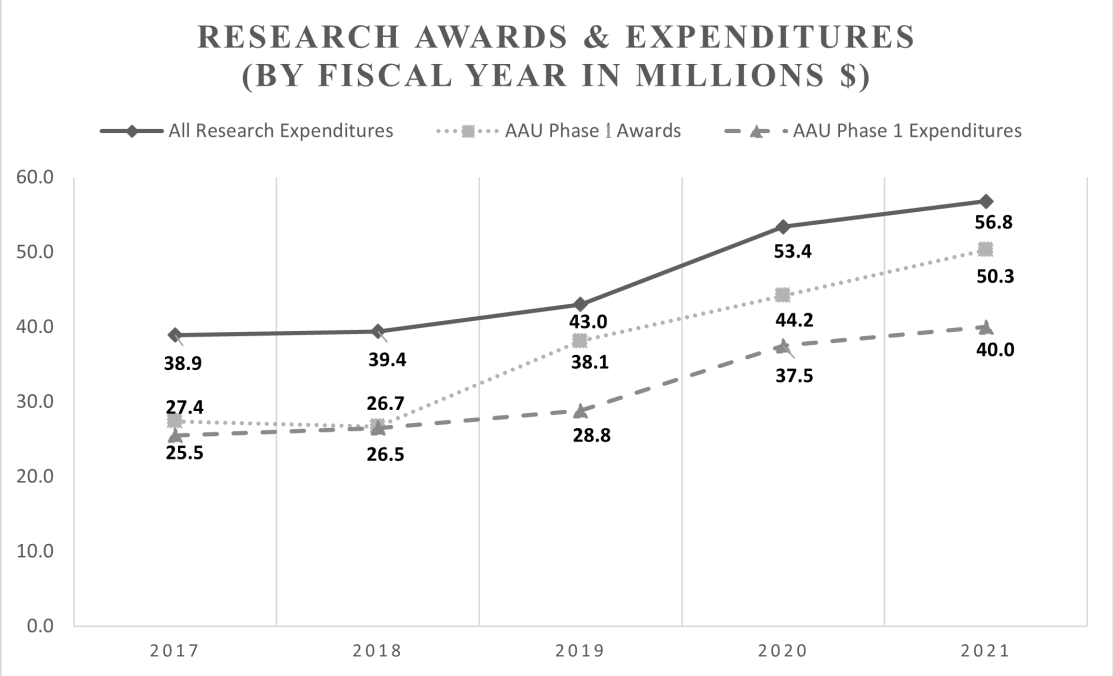

Figure 2. University of Missouri research metrics during COVID-19.

FY19 to FY20, our research expenditures increased by 9.7%. However, from FY20 to FY21, while our research expenditures did increase, the increase was only 2.6% (See Fig. 2, previous page). We believe this drop in our research expenditure growth and research award dollars was due to the COVID-19 pandemic. We have also seen substantial growth in AAU Phase 1 Awards, as noted in Figure 2, which is a leading indicator for growth in AAU Phase 1 expenditures (represented by the dashed line).

As a result of the COVID-19 pandemic, faculty began writing scholarly articles. There were 154 COVID-19 articles written by MU faculty over the last year, and these articles have received over 2,000 citations. Some of the projects involving COVID-19 research were quite cleverly designed. One example is the study "Mandated Societal Lockdown and Road Traffic Accidents" by Adnan Qureshi, MD, and colleagues.[2] The authors used the statewide Traffic Accident Records System maintained by Missouri State Highway Patrol to determine if the mandated stay-at-home policies led to a reduction in road traffic accidents or fatalities.

The University of Missouri Health Care Response to COVID-19

On March 13, 2020, the University of Missouri hospital (MUHC) initiated an Incident Command leadership structure, as did most academic health centers and hospitals around the country, and held the first meeting. Our first COVID-19 case was announced on March 17, 2020. The Incident Command infrastructure was led by Stevan Whitt, MD, and Mary Beck, DNP, RN. The Incident Command team consisted of the following leaders: Incident Commander, Ambulatory Section Chief, Logistics Section Chief, Infection Control Section Chief, Planning Section Chief, Vaccination Team, Liaison Officer, Public Information Officer, Finance Section Chief, and Human Resources Section Chief. The Incident Command team initially met twice a day, seven days a week. Initially, I joined these sessions virtually and found them to be quite beneficial as I was able to meet new colleagues at MU Health Care prior to being in Columbia to join in person. I was able to gain an awareness of their leadership roles and skills in a way that would not have happened during "normal times."

As previously mentioned, our highest daily census of hospitalized COVID-19 patients occurred in December 2020 and January 2021 (see Fig. 3). Figure 3 displays the daily COVID-19 inpatient census from the beginning of the pandemic to the submission of this article. By April 2021, our numbers dwindled, with some days showing we had zero to five COVID-19-positive patients in the hospital. Due to the surge of infections during the summer of 2021, case numbers increased. At the time this article was written (August 2021), our average daily census of COVID-19-positive hospitalized patients is 70 to 80.

An outcome of the COVID-19 pandemic was a dramatic increase in the use of telemedicine. Because patients could not come into the clinics, clinicians rapidly figured out how to see these patients via telephone or video. Our weekly telemedicine visits went from zero to 4,000 per week. However, with the waning of the pandemic, the number of telehealth visits has decreased dramatically (Fig. 4). Maintaining momentum in the effective use of telemedicine is a missed opportunity that is unfortunately occurring around the country.[3] It would be valuable to find ways to convince payers, doctors, nurses, and patients to continue to take advantage of the benefits of telemedicine in a post-pandemic environment.

There were other challenges and opportunities that resulted from the COVID-19 pandemic. Our hospital became full of very sick COVID-19-positive patients, and our team of providers and

Figure 3. Comparing the COVID-19 inpatient census to the number of telehealth visits that occurred between March 2020 through August 2021.

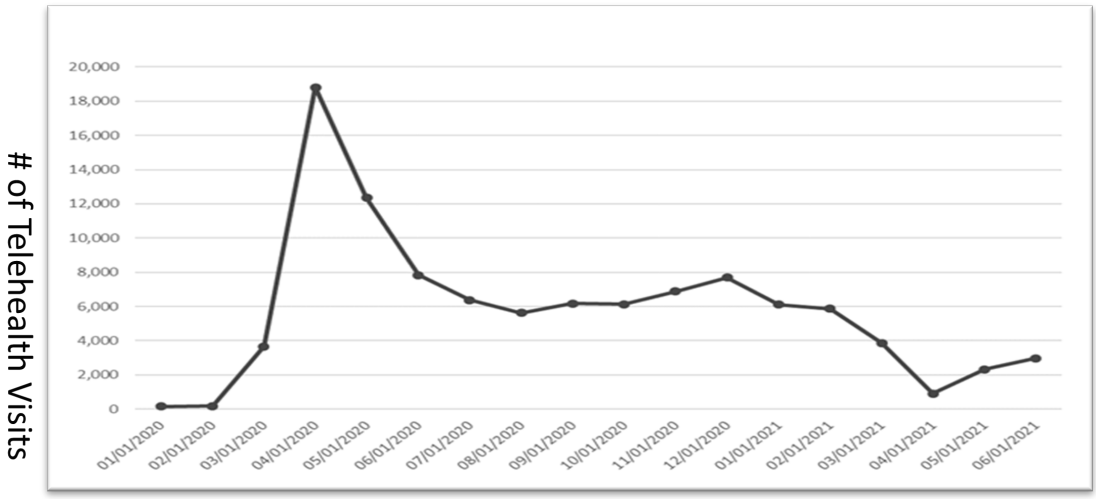

Figure 4. Changes in the volume of telemedicine visits between January 2020 and June 2021.

staff had to use all their skills to adapt to this new infectious challenge. It was a very stressful situation for our doctors, nurses, and other staff members. We witnessed significant burnout as the stress built up on these health care providers. Therefore, our health system leadership team and wellness program adapted to the situation by sending out daily messages to maintain confidence and morale. Everyone wanted to know what was happening as a result of the COVID-19 pandemic in an environment of rapidly shifting priorities, so hospital leaders set up weekly online town hall meetings to inform faculty, staff, and students of the situation in the hospital, on campus, and within the community. After the summer months of 2020, we decreased town halls to twice a month; then after the winter surge, we decreased the town halls to monthly, and we maintain them on a

quarterly schedule. This again may be a lost opportunity as many people valued these communication exchanges with leadership.

Quickly getting a vaccination system operational was another challenge. We initially set up vaccination clinics in the basement of the hospital but realized there was a community need for vaccination that was not being met by local clinics or local public health. We shifted the vaccination location to the University's football stadium where we could safely manage and vaccinate several thousand people a day. We contribute to a successful vaccination rate of over 50% among the citizens in Boone County.

Finally, the COVID-19 pandemic clearly had an impact on MU Health Care's financial position. In FY20, our operating income decreased to $47.5 million compared to an operating income in FY19 of $83.3 million. This was directly due to the shutdown of the hospital in the early months of the COVID-19 pandemic with the exception of COVID-19 cases and true medical emergencies. The shutdown essentially affected the last quarter of 2020. Fortunately, there has been a robust rebound in 2021, and we are expecting an end of academic year operating income of over $90 million.

The University of Missouri School of Medicine also had to pivot sharply because of the COVID-19 pandemic. We switched to a completely online program for our medical students in March 2020. By May 2020, we began allowing some students back into the clinic and hospital setting under restricted conditions. Currently (August 2021), we essentially are back to a pre-COVID-19 teaching environment for medical students, but that could change if the summer 2021 surge of infections and hospitalizations continue to increase.

On May 13, 2021, we held a COVID-19 recognition ceremony. We had an outdoor gathering for staff, faculty, and students where we shared a number of experiences. This was a time of remembrance and recognition. We had patients who lost loved ones to COVID-19 speak to the group and had survivors involved in the recognition event. This event of course did not bring full closure to the COVID-19 situation but was a very helpful and healing process.

Ongoing Challenges and Opportunities

As the COVID-19 pandemic continues to present challenges, we are prepared to make adjustments and seek opportunities to overcome obstacles. One of the challenges the University faces is faculty recruitment and relocation. Since the pandemic began, site and travel restrictions have made it difficult to conduct interviews and forced the elimination of site visits for potential new faculty. To address this, we conduct initial interviews via video calls. This solution may be adopted routinely going forward to save time and money on initial interviews. Second, the COVID-19 pandemic crisis has led to a housing shortage nationwide, and incoming faculty are finding it difficult to find homes to buy. A third challenge has been poor statewide vaccination uptake and risks from new variants of COVID-19. Because of this, we reinstated our mask policy in July 2021 across the MU Health Care campus. There is an opportunity to educate and inform the community about the importance of being vaccinated. While overall research has been challenged because of the pandemic, we see an increased opportunity for the NextGen Precision Health initiative at the University of Missouri. Initially consisting of three main research focus areas, the initiative now includes infectious disease research. Our Influenza+ Center includes COVID-19 research and is in the process of hiring additional staff and faculty.

The COVID-19 pandemic continues to have a global impact. Healthcare sys-

tems, public health, medical education, and clinical practice have responded to the challenge of dealing with a pandemic in innovative and impactful ways. From a system level to an individual level, creative problem solving and meeting the responsibilities to care for patients and communities have been a hallmark of our response. One of the greatest discoveries has been our ability to adapt and move forward to better serve our community.

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From Office of Research to Office of COVID Response & Field Research in the Time of COVID

John P. Carroll, PhD, Director and Professor, School of Natural Resources
Bob Wilhelm, PhD, Vice Chancellor for Research and Economic Development
University of Nebraska-Lincoln

The COVID-19 pandemic of 2020 through the current time has presented broad and new challenges for all of society. Research universities have been faced with many new demands and obstacles across all aspects of their operation. Field research, an activity that must commonly plan for disruptions and unexpected events, has had to be approached with even more creative and responsive efforts. Given that field research comprises a significant portion of the research portfolio at the University of Nebraska – Lincoln (UNL), the pandemic response at UNL and the response for continued field research are highly connected and strongly informed by each other.

This paper describes the broad response that UNL took in operating safely during the pandemic and the particular challenges of pursuing field research. In the following sections the university-wide response is first summarized. More detailed information and discussion are then presented regarding field research during the pandemic. Conclusions reflect on the effectiveness of the UNL approach and the way that university operations and field research were connected and informing.

The Broad Response of UNL to Safe Operations During the COVID-19 Pandemic

Early information about the COVID-19 virus was visible in news services as early as January 2020. Most activity in January focused on monitoring and some risk assessment for foreign travelers. The university opened as scheduled for the spring 2020 semester and operated much the same as past years. During February, organizing began within the university to manage return travel for all faculty and students outside the country. In early March, planning accelerated for different approaches to university operations. By mid-March, the university moved to remote operations for all activities.

The pandemic response at UNL was organized early to address all aspects of a research university. A campus-wide COVID-19 task force was formed, and it began coordinating a number of specialized committees to address academics, engagement, research, facilities, events, etc. In addition to committee assignments, the leadership and staff of the Office of Research were tasked with a number of new operational duties. This led to double assignments beginning in March 2020 and continuing through the present.

As the events of the pandemic unfolded, UNL first imposed very strong restrictions on campus presence, moving all academic programs to remote operations, curtailing all events and in-person engagement activity, and reducing in-person research activities to a minimum set of critical operations. Facilities management and other operations of the university were handled remotely when possible and by a small group of on-site personnel as required. The spring semester was completed with 100% remote instruction and minimal research activity at campus sites.

During May 2020, the university began organizing for further resumption of safe on-site activities and a proactive safety plan for the fall 2020 semester. An additional committee called Forward-to-

Fall was formed to undertake this task. The committee made use of regional and national expertise to develop a layered approach for safety and began working very closely with the regional public health department. The Forward-to-Fall plan depended heavily on the committees already supporting the COVID-19 response. In preparation for the fall semester, COVID-19 testing resources were organized in coordination with the State of Nebraska, and an integrated approach for contact tracing was developed in partnership with the Lincoln Lancaster County Health Department. A dashboard system was instituted to allow for monitoring of COVID-19 effects at the UNL campus.

During the summer of 2020, the Research Task Force worked with various research leaders to organize an approach for limited research activity that depended on detailed safety plans and significantly reduced density of people at campus research sites. Most all research activities returned to operation via these safety plans. Additional requirements were put in place for human subject research.

The fall 2020 semester opened slightly early with a new calendar that concluded the semester early as well. The majority of courses were offered with in-person options and research activity continued at campus sites with reduced density. Planning was also initiated for spring semester with initial emphasis on large-scale testing. The fall 2020 semester completed successfully and was followed by two shorter course periods in December and January.

The spring 2021 semester was scheduled to begin later and end earlier than previous years. By January 2021, UNL had created a large-scale saliva testing system for COVID-19 monitoring and increased the sophistication of the integrated contact tracing efforts. Planning also began to support vaccination of community and university populations. The spring 2021 semester completed successfully. At the time of this paper, planning is underway for continued operation of the university through the fall of 2021.

All of the planning and management of the UNL COVID-19 response has been made with a small number of principles in mind. Most importantly, the campus-wide committees and task forces have offered guidance with the expectation that a larger number of leaders and experts—distributed throughout the university—are empowered to make local decisions. The campus-wide groups have been formed with an inclusive composition of campus leaders, faculty, staff, and students. The approach of guidance and distributed management has governed operations in key areas: academic planning, budget, campus operations, research, student life, health, legal, international, information technology, and campus communications. This structure was created to enable a clear chain of command while fostering bi-directional communication. Quick communication was encouraged, supported, and expected to support the rapidly changing operations approaches that have evolved from spring 2020 to the present. Finally, there has been a persistent effort among the campus leaders to plan carefully, communicate clearly, and lead both authoritatively and optimistically.

Field Research: Challenges and Learning During the Pandemic

The pandemic impacts on university operations were far reaching and required multiple levels of planning and mitigation. Field activities, especially research, provide some unique contrast to the sorts of planning that needed to be done for on-campus activities ranging from teaching to lab-based research. Interestingly, field research of all types often has far larger components of externalities that make the levels of uncertainty surrounding the research much more

vulnerable to perturbations in systems and other factors outside of the control of the researchers. Research outside the constraints of a university campus is often accompanied by elevated risk to the research and researchers (Williams et al., 1992).[1] Although we commonly think of field research in the context of certain fields of endeavor, in reality a wide range of academic disciplines—from the biological and physical sciences to anthropology, sociology, and public health—share many common potential issues due to the nature of the disciplines.

Although on-campus and off-campus researchers may face similar types of outside factors, often the vulnerability of the research and researchers is much greater when the security of campus is left behind. For example, crop research, like the important corn and soybean work being done at UNL, often faces broad weather vagaries within a growing season despite our desire to control variability of conditions. Any researcher undertaking field work on these crops faces uncertainty every year that the whole program can be significantly and negatively impacted by a simple weather event, such as a hailstorm. A short, but by no means inclusive, range of factors that has severely impacted research programs for field-based faculty and staff includes natural disasters such as floods and earthquakes, human impacts such as public interference with study areas or organism, criminal behavior and theft, threats against personnel, and political upheaval (Grimm, 2017; Paterson et al., 1999; Phalen, 2017).[2,3,4] Even within teams, the fact that research teams are often located in areas without the support network of the university can create dynamics that increase the uncertainty of smooth data collection and/or safety for personnel.

Despite the need and often preparedness of field researchers for all potential contingencies, there are few times in history, at least in U.S. history, where the external forces have caused such a "perfect storm" of conditions.

COVID and Field Research

Over the last 18 months of the pandemic, what has become clear is that many of us who undertake field research and our institutions were not as prepared to deal with the "COVID disaster" as our risk management planning might have led us to believe. In part, our risk and emergency planning often focuses on two areas that created weaknesses in our response to this emergency. We tend to focus on risk and emergencies as incidents rather than processes. So our planning focuses on preparing for an incident, responding during the incident, and then recovering. Temporal scales are more of a point in time rather than something covering a long period of time. In addition, geographical scales of incidents can range from local, where a researcher might have to deal with field issues, to regional, where research sites are destroyed or research interrupted by a major disaster, such as a hurricane (Beggan, 2010).[5]

With the COVID-19 pandemic we found ourselves in a situation beyond the typical incident type of timeline and a geographical scale that was global. Contrary to most incident-based events, COVID-19 resulted in research shutdowns over long periods of time and over very large geographical areas. Among field researchers our experience was that there was a range of underlying factors that impacted the ability of the research enterprise to continue.

As the pandemic unfolded in middle America, universities scrambled to assess how to respond. Broadly there were often two groups of responses, depending on whether activities were on campus or off campus. In many cases, like our university, the off-campus work was effectively "paused" for an extended time. In most cases, allowable research activities off campus were phased in. For example, at UNL, very restrictive travel to

local and within state research sites was allowed and then over time followed by even more restrictive requirements for traveling beyond state political boundaries. That was then followed by allowance of some research activities on an international basis.

Scale was important because ownership of locations where research was being undertaken, along with political boundaries, resulted in a variety of rules and lockdowns that were implemented in a fluid way at best. Layered on top of accessibility were rules that also dictate how research can be done, including guidelines on human (IRB) and animal (IACUC) use in research and welfare considerations for both groups. Animals in confined situations outside campus-based facilities and wild animals that might have already undergone treatments or incorporation into research projects were particularly problematic in balancing risk and welfare of the subject and the researchers. In addition, calendar-sensitive research resulted in difficult decisions on whether research activities should be suspended all together versus some dispensation for allowing minimal activity. Here at UNL, animal welfare dictated that care of research animals on a number of properties take priority. In addition, wild animals already included in field research prior to the pandemic required prioritization of data collection while most projects where paused. On many of our crop sites, research fields were planted with permission to allow a growing season to proceed in case conditions changed enough to allow data collection in light of the uncertainty of how the pandemic would unfold. Of particular concern during the pandemic were operational entities within our research portfolio that require off-campus data harvesting from multiple sites. Many universities now manage weather Mesonet systems, and here at UNL we also manage the groundwater well monitoring system for Nebraska. Those systems require uninterrupted management and data flow for both contractual and legal obligations, but also as part of networks that feed into a range of societal decision-making processes. For example, in a highly irrigated state like Nebraska, agricultural producers depend on those data systems to make decisions about irrigation scheduling.

Finally, the most critical component of the university research enterprise is the workforce. The pandemic impacted segments of the workforce in broadly different ways. The most vulnerable of these segments identified were graduate and post-doc students. Most of these individuals are in positions that are time dependent and tied to contractual responsibilities. These are followed by staff who oftentimes at universities feel they are most expendable. Stress related to workplace uncertainty also raises the issue of mental health of the workforce (Sharma et al., 2020).[6] Again, communication was critical in our programs with flexibility for decision making at the local level to develop strategies allowing the lowest possible impact on research tied to education, but also assuring staff that budget considerations would prioritize active personnel above other potential cuts. These steps during periods of great uncertainty allowed morale to be maintained and allowed us to reengage research very quickly as conditions improved.

Conclusion

Although field researchers often have experience and training in dealing with a wide range of risk factors and disasters, that experience is much more focused on local and project-specific factors. COVID-19 is simply at a spatial scale that is unprecedented. In addition, risk planning is much more of a short-term incident focus whereas COVID is over a much longer time frame and one that resulted in no "end" date to the disaster. In

effect, risk management for this pandemic is probably more analogous to climate risk management than typical disaster planning (Jones and Preston, 2011).[7]

Despite the lack of strategic planning for a disaster of this magnitude, we developed adaptive strategies during the pandemic that resulted in minimizing impact on researchers while ensuring safety of faculty, staff, and students—at the same time creating a sense of confidence that the university was supporting our team in allowing work to proceed in a safe manner.

Strategies adopted at UNL that we believe helped us cope with the pandemic more effectively include communication flow in both directions between researchers and upper administration; implementation of broad policy decisions by upper administration, allowing flexibility at program levels to account for the broad variability of conditions and needs; and flexibility to adjust over time to changing conditions. There was also the recognition that pausing research dramatically impacts different members of our research enterprise in different ways. For example, although senior faculty might have their research impacted by a pause, graduate students and post-docs had their careers impacted in a much more direct way. Assurances of accommodation, especially for students who were delayed coming to UNL, and a support network, including salary support, gave students the confidence that they could continue their programs and instilled trust in university leadership.

Within the university research community, field researchers have a history of working with a much broader range of risk factors beyond the boundaries of the university campus. A possible solution model might be found in the adoption of risk management teams now found at many universities for dealing with risk management associated with international research and other travel. As a model for developing risk planning, these committees assist researchers in weighing cost, benefits, and risk in a strategic way before international work takes place.

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Junior Faculty Research Career Development in the Era of COVID-19

Kimberly Kirkpatrick
University Distinguished Professor
Department of Psychological Science
Kansas State University
https://orcid.org/0000-0002-6633-9782

This article is written from my perspective as the director of a Phase 1 Centers of Biomedical Research Excellence (COBRE) grant that established the Cognitive and Neurobiological Approaches to Plasticity Center (CNAP; www.k-state.edu/cnap) in July 2017. CNAP is located within the Department of Psychological Sciences on the central campus of Kansas State University (K-State) in Manhattan, Kansas. CNAP researchers study cognitive and neural plasticity in animal models, as well as conduct basic and clinical research in humans. Phase 1 research has focused on a variety of brain regions and circuits associated with diseases and disorders that impair healthy brain function (**Figure 1**). Researchers have studied multiple diseases and disorders in humans and in animal models, including alcohol and substance abuse, obesity, autism spectrum disorders, Parkinson's disease, Alzheimer's disease, hearing disorders, post-traumatic stress disorder, and attention deficit/hyperactivity disorder.

CNAP Mission

The fundamental mission of the CNAP COBRE program is to develop faculty research careers, with particular emphasis on aiding them in securing R01-level extramural research funding. We support faculty through two funding mechanisms: (1) research project grants supply two to three years of funding at $125-$160K per year, and (2) pilot grants provide one to two years of funding at $25-$100K per year. Both grant mechanisms set expectations that the supported faculty member should regularly apply for extramural grants. CNAP faculty have full access (without any user fees) to outstanding core facilities that provide access to cutting-edge technologies and techniques. Core facilities include a Behavioral Neuroscience (BN) Core that supports animal neuroscience research, an Electroencephalography (EEG) Core that supports human cognitive neuroscience research, and a Neuroinformatics (NI) Core that supports data storage, handling, and analysis for large neuroscience data sets. Dedicated technician support and scientific skills training ensure that core facility users have the necessary tool kit to take full advantage of the core facilities. In addition, our Scientific Exchange Network consists of multiple centers and core facilities in the region and

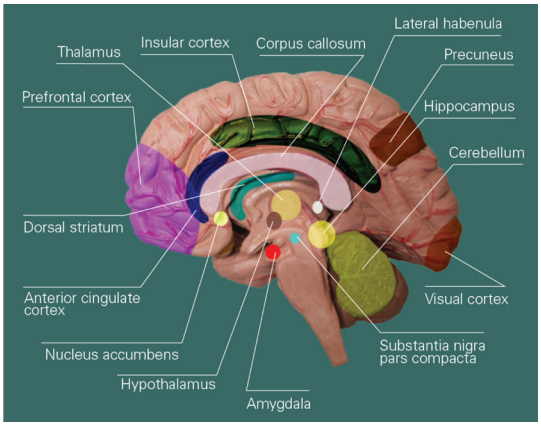

Figure 1. Brain regions and circuits that have been studied by CNAP-funded junior investigators conducting research on cognitive and neural plasticity.

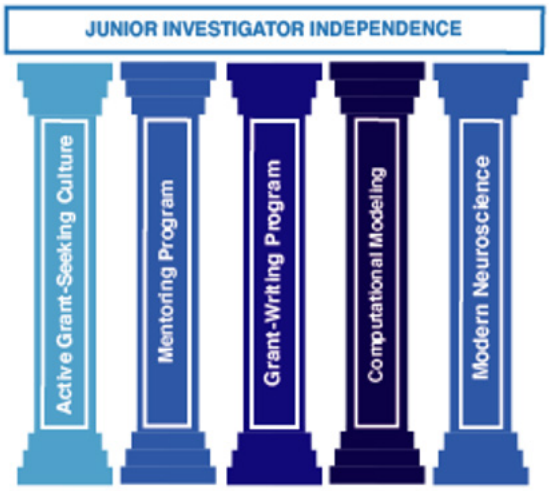

Figure 2. Five pillars of success to promote investigator transition to independence.

facilitates access to additional research facilities and training.

To maximize our ability to support junior faculty in their quest to obtain independent R01-level funding for their research programs, CNAP uses a faculty development model that involves five pillars of success to support junior investigators (**Figure 2**).

- Pillar 1: Our first initiative early in Phase 1 was to establish an active grant-seeking culture which substantially increased proposal submissions over the first three years of COBRE support (see **Table 1**). Increased proposal submissions increase the likelihood of investigator independence by creating more opportunities for success.
- Pillar 2: We established an outstanding mentoring program to ensure strong support for junior investigator development. Mentors, who are recruited nationally for their research expertise and strong faculty mentoring track records, meet at least monthly with CNAP faculty and provide support for research program development, feedback on manuscript and grant submissions, and guidance for career development.
- Pillar 3: We implemented a grant writing program to increase the quality of grant proposals. The grant writing program has evolved and developed over time into a scalable, formal program designed to promote high-quality applications. We supply a library of materials, including examples of successful grants and common supporting materials (biosketches, facilities, equipment, and budgets). We also facilitate researchers in obtaining scientific pre-reviews, and we conduct thorough in-house technical reviews of grant proposals.
- Pillar 4: Advanced computational modeling is a growing priority area for funding agencies, and the CNAP NI Core supplies cutting-edge technologies to support neural computation, advanced statistical modeling, and machine learning approaches.

Year	Present	Pubs	Proposals		Awards	
			#	$	#	$
1	9	0	0	$ -	0	$ -
2	36	4	11	$ 9,415,632	3	$ 2,086,310
3	46	14	32	$ 14,922,661	13	$ 1,675,310
4	41	25	41	$ 21,698,536	10	$ 868,183
5	6	4	8	$ 5,694,115	5	$ 3,598,959
Total	**138**	**47**	**92**	**$ 51,730,944**	**31**	**$ 8,228,762**

Table 1. Total presentations, publications, proposals, and awards directly supported by CNAP.

We anticipate that many grant agencies will expect applicants to routinely incorporate these methods within the next few years, so we aim to put our investigators ahead of the curve so they can write competitive applications with a high degree of scientific rigor.

- Pillar 5: Access to modern neuroscience techniques through the BN and EEG Cores provide the final pillar of success. These techniques ensure that researchers can collect data using cutting-edge neuroscience techniques so that they can compete for R01-level funding.

COVID-19 Impacts on CNAP Research

On March 12, 2020, K-State President Richard Myers announced that the university would close the campus to in-person classes starting on March 16. Restrictions on research facilities followed soon after. At the time when COVID-19 began to unfold, we were just entering the final quarter of Year 3 and CNAP had graduated one investigator to R01 status, three other investigators had received extramural grants, and one further investigator had received a competitive score on an R21 grant. Our conference presentations and grant proposals were rapidly escalating. The research cores were successfully creating thriving research environments with rapid increases in users. Overall, we were well on track to be competitive for having our COBRE grant renewed for a second phase of funding.

The implications of COVID-19 for CNAP-supported research were substantial and profound.

Human research was strongly impacted in the following ways:

- Prior to COVID-19 onset, Psych Sciences supported a large subject pool consisting of students enrolled in undergraduate courses who could participate in research for course credit. With students not returning to campus, the subject pool became unavailable for in-person research, and this remained the case until August 2021.
- Many of the CNAP-supported research projects involved testing higher-risk groups such as older adults. Those projects have been unable to conduct in-person research since March 2020.
- The EEG Core facility was closed to in-person research from March to August 2020 and then operated under restrictions that limited research capacity from September 2020 to August 2021, resulting in a slower pace of research than normal. This facility continues to operate with many precautions, including mask-wearing and additional cleaning. This facility has not had any known or suspected cases of transmission of COVID-19 at any point during the pandemic, so the safety protocols have been highly effective.

Animal research was also heavily affected, but in different ways:

- The BN Core remained open throughout the pandemic, but from March to August 2020 researchers were only able to complete ongoing live animal research. New studies were not permitted. In addition, researchers were only allowed to conduct work with brain samples if that work was time sensitive (i.e., samples would be lost if not processed). From September 2020 to May 2021, the BN Core returned to supporting the normal range of research activities but with restrictions on research capacity (e.g., animal numbers) and staffing to facilitate social distancing. These measures translated into a slower pace of research than normal.
- Animal facilities at some of our partner organizations that CNAP-funded faculty relied on were closed from March to August 2020, so

those faculty were more heavily affected.

- Since June 2021, the BN Core has been gradually ramping up research and staffing to return to pre-COVID activity levels. The core continues to operate with additional precautions, such as mask wearing, additional cleaning, etc. This core has not been associated with a single instance of COVID-19 transmission throughout the pandemic, so the safety measures were highly effective.

In addition, both animal and human research laboratories were affected by:

- Undergraduate research assistants having limited access to the campus. There were many undergraduates working in laboratories, and they were not allowed to participate in on-site research from March to August 2020 and then only in limited numbers from August 2020 to May 2021. The loss of undergraduate assistants affected junior faculty more significantly as the staffing of their laboratories was not as developed. Junior faculty didn't have the graduate students and research staff that senior faculty could rely on.
- Loss of time-sensitive materials, such as chemicals and reagents that expired.
- Challenges with supply chains, which delayed deliveries of critical materials.
- Struggles with poor remote access to data, software, and other resources. In some cases, the challenges were due to issues with home internet access or speed. In other cases, the software, data, or other resources were on campus computers and could not easily be transferred.
- Conference and workshop cancellations, which resulted in loss of opportunities for professional development and networking opportunities. This loss affected junior faculty more heavily than senior faculty as networking and professional development are often more critical to early-stage career development.
- Workload issues, including having to redirect significant time to retooling courses and increased administrative burdens due to COVID-related emergency planning.
- Childcare challenges due to daycare and school closures. Faculty with young children suddenly had to take on the responsibility for childcare and home-schooling.

As a result of these varied and substantial impacts, we suspect that the pandemic suppressed our graduation of faculty to extramural funding. Data collection was slowed to varying degrees from March 2020 until August 2021 when the university fully phased out of COVID-19 related restrictions on research. The COVID-19 restrictions translated to delays in submitting and resubmitting grants. We were on track to have an even larger increase in Year 4 proposals (see **Table 1**), but this was not fully realized. In addition, the delays in data collection most likely diminished the quality of proposals by reducing the amount of preliminary data included. You can see evidence of this effect in the suppression of funded grants in Year 4 (**Table 1**).

It is not surprising that we saw these adverse effects on the productivity of our project and pilot grant leaders as there are many reports of the negative impact of COVID-19 on junior investigators, particularly in STEM fields such as neuroscience ("A conversation on the effects of the COVID-19 pandemic on junior researchers' careers with funders and university leaders," 2021; Lowe-Power et al., 2021; Myers et al., 2020; National Academies of Sciences & Medicine, 2021).[1,2,3,4] Neuroscience has been one of the most heavily affected disciplines because of the reliance on access to special (often vulnera-

ble) populations and highly specialized equipment and facilities (Myers et al., 2020).

CNAP COVID-19 Mitigation Strategies

Because we were nearing the end of Year 3, and some projects were scheduled to end, our first COVID-mitigation strategy was to grant an automatic no-cost extension for up to 12 months for all grants that were scheduled to end on May 31, 2020. Because COBRE funds do not automatically carry over, this meant we had to use Year 4 funds to cover these extensions and thus couldn't fund as many new awards in Year 4. However, we felt it was critical to support the junior faculty that were being actively funded to ensure that their grants could be successfully completed.

One challenge that some researchers faced was that they were funding salaries for staff who were unable to work at full capacity. We were able to turn this challenge into an advantage by using central funds to partially fund the salary of a technician in a senior faculty's laboratory who was not working at full capacity. Their time was used to cover animal care and daily research activities in junior investigator laboratories, thus partially mitigating the impact of the loss of undergraduate student support on their laboratory functioning. We also purchased laptops, special software, and portable equipment to support remote work. The CNAP core facility directors developed alternative plans for supporting research, including shifting training workshops to remote format, extensive development of safety protocols for in-person animal and human research, and developing innovative tools to support remote analytics.

Our most extensive mitigation strategy involved the transition of human research to a remote testing format. Given the complex nature of CNAP research, which often involves dynamic tasks with video stimuli, precisely timed stimuli, rapid decisions, and/or eye tracking measures, the transition to remote testing required overcoming significant technical challenges. We were able to transform several research programs to a remote testing format. For example, one project involved testing older adults and their ability to use their knowledge of familiar tasks to promote everyday memories. This study involved training older adults to learn a new skill and then testing their ability to dynamically recognize key elements in a subsequent video demonstration of that skill. Another task involved simulating eye movements using a mouse-blur paradigm where individuals can clarify a small part of an image to simulate an eye movement. This task was superimposed on video stimuli while participants were making decisions. To our knowledge, the mouse blur task has never been used with video stimuli, so our study resulted in a technological breakthrough in generating a new methodology. Although the transition to remote testing required several months of intensive programming and troubleshooting, we were able to promote the success of our human researchers working with vulnerable populations much more quickly than would otherwise have been the case.

Following completion of the transition to remote human research, we created an online course to provide step-by-step instructions for experiment set-up in different platforms, disseminate special research materials that our team created, supply code for custom programs, and provide tutorials for specialized tools required for remote research. These resources have been disseminated to our broader CNAP research community so that other researchers can benefit from the tools that we created.

Another key mitigation strategy that we employed was to create alternative research plans that could be enacted to deal with COVID-19 challenges. Each funded

project and pilot grant leader developed a set of emergency plans for their research programs in July 2020 and these were submitted to our COBRE program officer for approval. The plans were developed in close consultation with their mentors. This provided an avenue for researchers to have funding agency-approved alternative plans, timelines, and strategies to ensure they could be successful even in the face of ongoing challenges.

The COBRE program has extensive evaluation and reporting requirements, and the projects, pilot grants, and core facilities are evaluated three times per year. We practice strong transparency in our evaluations with clear expectations and well-prescribed assessment practices. Because we had developed mitigation strategies, we were able to tie those into the evaluations. We were already collecting reports on challenges and proposed changes and this reporting was expanded to include COVID-19 challenges and enacting of alternative plans. We continued to evaluate as normal otherwise and were pleased to discover that our faculty were in many cases faring surprisingly well. I have been amazed by the creativity and tenacity shown by CNAP junior faculty in facing the challenges of COVID-19. In cases where faculty were struggling, the regular evaluations provided an avenue to gather information on the ongoing challenges and adapt our mitigations to get those faculty back on track relatively quickly. In addition, we were able to assess the efficacy of our mitigation strategies so we could adapt as needed or continue elements that were working well.

Impact of COVID-19 on Women Junior Faculty

While there have been impacts of COVID-19 on most researchers, women in STEM fields such as neuroscience reported larger decreases in productivity than any other group (National Academies of Sciences & Medicine, 2021; Reardon, 2021). One major reason for this difference is that women are more likely to be responsible for childcare and elder care. As COVID-19 resulted in school and daycare closures, 71% of female researchers reported increased childcare demands (Reardon, 2021).[5] As early evidence of the impact of the pandemic on women scientists, first-authored journal articles by women decreased by 14% in March and April of 2020 in comparison to the same timeframe in 2019 (Andersen et al., 2020).[6] An additional study found that female scientists overall showed a 5% larger decline in research time than male scientists, and female scientists with children under five years of age experienced the largest impact on their research time (Myers et al., 2020).

In terms of CNAP outcomes, we noted that several of our female faculty were struggling with special challenges caused by the pandemic. We engaged our mitigation strategies to partially offset some challenges. For example, we were able to provide significant staff support (by redirecting technician time) for two of our female junior faculty for covering animal care and basic research activities. This helped offset the combined effects of the loss of undergraduate support, increased workloads, and increased childcare demands.

Over Years 1-4 of CNAP, we have funded 14 grants to 11 faculty and have delivered approximately 48% of our project and pilot grant support to female junior faculty. Because our sample size is relatively small, we are unable to analyze the data by year, but we can see overall performance trends (Table 2). The female faculty delivered more presentations but had fewer publications (even when controlling for differences in support). Regarding grants, the male faculty submitted more grants, but the female faculty submitted many more large grants. Female faculty funding rates were lower, but their total dollars were higher. Overall, the patterns suggest that the

			Proposals		Awards	
	Present	**Pubs**	#	**$**	#	**$**
Female	57	15	28	$ 26,856,783	5	$ 2,577,091
Male	52	20	38	$ 8,525,853	18	$ 1,448,733
Total	109	35	66	$ 35,382,636	23	$ 4,025,824

Table 2. Products generated by grant-support male and female junior faculty over CNAP Years 1-4.

female faculty were aiming higher in the grant domain.

We have also been able to make close individualized observations of the effects of COVID-19 on CNAP junior faculty and feel that many of our mitigations were successful in reducing the gender gap, and in reducing COVID-19 impacts on research productivity generally.

Institutional Support

As an incubator for faculty development, the CNAP center provides a means to understanding the impacts of COVID-19 on faculty and assessing the effects of mitigation strategies on key outcomes. There are many lessons that we can learn from our COBRE that could potentially be applied at the broader institutional level.

One key lesson that we learned is that evaluations, when conducted with the goal of promoting success, can be an important tool for assessing COVID-19 impacts and efficacy of mitigation strategies. Another significant lesson is the importance of developing alternative plans and transparent guidelines to account for COVID-19 impacts within evaluations. Assessment guidelines can be adapted at institutions to address challenges by incorporating COVID-19 impact statements. Short-term alterations in metrics for quantitative measures of productivity may also be warranted. For example, evaluations could focus on article submissions rather than publications to account for reduced research time and other delays. Similarly, grant submissions may be a better indicator than funded proposals. This can accommodate challenges that junior faculty may have experienced in having limited preliminary data to support their proposals, which may have decreased their competitiveness. We found in Year 4 that funded proposals decreased, but grant submissions increased (**Table 1**). This suggests that the reduction in funded proposals was not a product of decreased efforts to obtain funding.

Most institutions granted automatic tenure-clock extensions. While this measure can help some faculty, tenure clock extensions by themselves are likely insufficient (Butler, 2021).[7] Because COVID-19 affected researchers in many ways, promotion and tenure expectations should be tailored to reflect individual experiences. For example, faculty could develop individualized plans and goals that could be used as yardsticks for assessment with COVID-19 impacts factored in. The plans and goals can be tuned to reflect differences in access to resources and opportunities because of the pandemic. We found that individualized COVID-19 plans allowed our COBRE center to maximize support of junior faculty and promoted adaptability in pursuing solutions.

We also found that delivering automatic no-cost extensions to our Year 3 grants meant that the research activities on those projects were completed in Year 4. Without those extensions, this outcome would not have been possible. At the institutional level, universities should automatically extend expiration dates on start-up funds. Universities could also

advocate for faculty to receive additional extensions to their extramural funding contracts.

Another key factor with the COBRE mechanism is that project leaders must devote at least six months of effort per year to their projects. This ensures that faculty have protected time so that they can focus on developing their research careers. The standard teaching load at K-State is 2-2 but COBRE project leaders have a 1-1 teaching load. This led to some buffering of the impacts of COVID-19 on increasing workloads, particularly in the teaching domain. For faculty who did not have the benefit of protected time, institutions should consider granting one to two semesters of release time from teaching and service expectations so that faculty can work to regain their pre-COVID research career trajectories. These could be treated as pre-tenure sabbaticals to promote faculty in their ability to achieve tenure on their pre-COVID timelines.

COVID-19 Silver Linings

Although the pandemic produced widespread negative impacts on our COBRE center, we also experienced multiple benefits. We now have excellent platforms for conducting high-quality remote cognitive testing of human participants. And those platforms have created opportunities to access populations that are not widely available for in-person research (e.g., under-represented groups, individuals with diseases and disorders, and individuals outside northeastern Kansas). In addition, the development of remote analytics tools significantly increased research capacity as researchers can now conduct advanced modeling techniques either on-site or remotely. We were able to buffer faculty against major career impacts and, in doing so, learn new ways of supporting junior faculty. We also developed more flexible and responsive decision-making strategies that will allow us to respond better to future challenges. In the long-term, these positive outcomes could be translated into new approaches to faculty development and evaluation within their institutions that could significantly benefit faculty research career development in general.

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Post-Pandemic Directions for Aging Care Research

Kristine Williams
E. Jean Hill Professor
University of Kansas School of Nursing

The COVID-19 pandemic changed the world for everyone, but especially for older adults. With age established as the primary risk factor for severe illness and death, older adults were disproportionately affected (Lebrasseur et al., 2021), and life expectancy declined for the first time in recent history (Andrasfay & Goldman, 2021). The first reported death from COVID-19 was a nursing home (NH) resident, and to date (September 2021) approximately 25% of deaths from COVID-19 in the United States were nursing home residents (Abrams, 2021). As the nation emerges from the pandemic, this crisis represents not only the danger of continuing deaths, lingering variants, and pockets of low vaccination rates, but also the impetus and opportunity to improve care for aging adults. Improving ongoing aging care must take into consideration both the lessons learned during the pandemic and the new solutions envisioned. Positive care changes such as telehealth should be continued and further expanded, while new measures to reduce the negative impact of infection and isolation in institutional care settings must be identified and implemented in practice (Convergence, 2020; Edelman et al., 2020).

Healthcare consumers of all ages suffered negative effects of the pandemic due to reduced access and postponement of preventive and health promotion care and elective surgeries. In 2020, cancer screening declined by an estimated 80%, and other preventive and health promotion care such as dental cleaning and community based supportive care programs such as Meals on Wheels and adult day care were halted (Greiner et al., 2021; Lebrasseur et al., 2021). Even exercise was adversely affected as older adults were cautioned to avoid contact with others out of doors, as well as in gyms and group exercise classes. The impact of social isolation may have had the greatest impact on older adults; increased substance use and negative lifestyle changes were common while mental health services became less accessible.

For older adults requiring supportive care in long-term services and support settings (LTSS) ranging from home care to skilled NH care, dramatic changes occurred (Lebrasseur et al., 2021; U.S. Department of Health and Human Services, 2021). Of the adults 65 and older in the U.S. receiving Medicare, an estimated two out of five recipients who lived in NHs in 2020 were diagnosed with either COVID-19 or likely COVID-19. The number of Medicare NH beneficiaries dying per day increased by approximately 1,000 in 2020 compared to 2019; overall annual NH mortality rates increased from 17% in 2019 to 22% in 2020. COVID disproportionately affected 50% of Black, Hispanic, and Asian NH residents compared to 41% of white residents (Andrasfay & Goldman, 2021). Excess deaths and subsequent hesitancy for placing older adults in institutional settings have contributed to estimated declines in occupancy of 25% for NHs and other LTSS. For those businesses, the decline in occupancy rates is problematic, prompting some facility closures (Lawhorn, 2021).

However, these dramatic changes may provide impetus for positive changes in provision of care across LTSS.

NH care has long been identified as lacking quality and person-centeredness. Infection control has been a leading issue with renewed focus during and after the pandemic. The punitive nature of regulations and inspections has been pervasive in NHs, resulting in a culture that does not embrace quality improvement as other healthcare settings have done. NHs have been slow to adopt quality improvement initiatives and have been less likely to change practices based on research evidence. Emerging from the pandemic, NHs and other settings caring for aging adults have a critical need to invest in and endorse research and the evidence it provides to improve care (Edelman et al., 2020). This paper highlights topic, policy, and infrastructure directions for research to leverage improvement in care for older adults in the post-pandemic world.

Improving Nursing Home Care

Infection control became an essential priority for NH care during the COVID-19 pandemic. The Centers for Medicare and Medicaid Services (CMS), which regulates skilled NHs, responded to the early recognition of deaths among NH residents by mandating personal protective equipment (PPE) use and isolation precautions that undoubtedly prevented even more resident deaths. Initially NHs were challenged with shortages in PPE supplies; currently infection control practice changes are issued frequently, requiring prompt responses by NH administrators and altered practices for staff.

One sequela of heightened infection control was social isolation experienced by NH residents whose group activities were suspended. This resulted in lack of socialization for residents and inability for staff to assist and interact with multiple residents in groups, such as during group dining. Visits from family members that previously supported resident well-being were curtailed, further contributing to resident isolation and increasing dependence on staff for socialization and emotional support. Added time required for putting personal protective equipment on and off when in contact with residents and other infection control precautions limited staff and resident contact, further decreasing interpersonal interactions. Social isolation increases loneliness, contributing to depression, anxiety, fall risk, decline in function, dehydration, malnutrition, behavioral symptoms, and even suicidal ideation (Edelman et al., 2020). Limited mobility from resident confinement to rooms coupled with increased demands on staff time contributed to pressure injury risk, as well as urinary tract infections. Although these physiological and psychosocial issues exacerbated long-standing concerns about NH quality, they present an opportunity to improve NH care.

Infection control may be improved by moving to private resident rooms and using technology to connect residents interpersonally and more efficiently to staff or by grouping small numbers of residents in pods, limiting social contacts while optimizing socialization. Increased use of telemedicine within NHs would help overcome the need to access care outside the NH. Increased use of electronic records for charting, not widely implemented in NHs to date, can enable all levels of staff to document and share information electronically, critical for improving communication, clinical decision making, and reporting. Research is needed to explore these opportunities for improvements and how best to implement

them for positive change. Others suggest that approaches used in other countries and technology common in acute care settings, including extending staff care with monitoring systems and even featuring telepresence interactions with staff, may be adapted to resolve NH care quality issues (Edelman et al., 2020).

Inadequate staffing was accentuated by the pandemic. Staff who were exposed to or diagnosed with COVID-19 were unable to work. The increased time for attending to PPE and private rooms to provide individual care also increased the workloads for staff. Staff training must be adaptive, focusing on priority issues such as infection control updates. Asynchronous training sessions, such as online education, may best meet the just-in-time needs for access by multiple, increasingly busy staff. Training must also focus on making pandemic-level care person-centered, such as in training staff how best to communicate with a resident with dementia or a hearing loss while wearing PPE.

Most direct care staff are certified nursing assistants (CNAs) who have limited training. Over the past year, training requirements were relaxed to make hiring of adequate staff feasible but often overlooking the importance of training. Many CNAs and other NH staff work at multiple care facilities, increasing the risk for spreading infection. Notably, a number of states report that less than 50% of NH staff have opted for COVID-19 vaccinations (Data.CMS.org, 2021). These continuing issues have hampered the elimination of COVID from NH care. Strategies to hire and train direct care staff, limit cross-facility transmission, and promote vaccination need to be addressed by research to identify evidence-based solutions.

NHs serve the frailest older adults, so it is not surprising that NHs have been the most affected of the LTSS. LTSS range from supportive community-based services (home care, Meals on Wheels, adult day care) to congregate senior living settings and assisted living, including memory care. These other settings experienced lower rates of excessive deaths during the pandemic. Approximately one-third of NH residents died annually prior to COVID. This increased to approximately 60 deaths per 1,000 NH residents. In comparison, community-dwelling older adults died at a rate of six to seven per 1,000, and assisted living deaths reached 19.3 per 1,000 residents during 2020. These statistics suggest the need for research to support older adult residency at home or in less intensive LTSS and for research to develop and test interventions to maintain functional status and ability to manage everyday living, thus reducing progression to higher levels of care (NORC, 2021).

Improving Care Beyond the Nursing Home

Rethinking nursing homes in favor of more community-based models has been suggested, and this approach may be timely considering estimates that only 15% of those 65 and older will not need long-term care as they age. Over 50% of older adults will require assistance with multiple activities of daily living for over one year (Abrams, 2021; Belbase et al., 2021). Technology advances can help support ongoing community residency; however, the role of technology is limited and cannot totally replace human contact. Policy and current reimbursement barriers must be overcome to increase the availability of care at home. This includes funding to purchase technology to avoid disparities related to the socioeconomic status of many older adults with limited income. Many services deemed

custodial or not requiring skilled care are not covered or are covered sporadically. For example, extended supportive care is available through Medicaid to prevent NH placement, but many states limit the number of persons who receive these services, resulting in long waiting lists and unmet needs. Programs such as PACE, the Program of All-Inclusive Care for the Elderly, that integrate medical, behavioral, and social care for frail older adults under a capitated managed care system with a goal of autonomy and maintained community living are showing increasing evidence of success and can serve as a model for potential expansion (Eng et al., 1997). Rural areas often lack the range of services and infrastructure such as broadband access to support telehealth, and these issues also must be addressed.

An estimated 53 million, or one in five, Americans provide care for older adult family members and friends at home, including a large proportion of those diagnosed with dementia (Retirement Research Foundation, 2021). Paying family caregivers is one suggested approach to support home care. Research on how to best support families to reduce LTSS needs is critical (Teshale et al., April 2021). Research and policy must address other innovative approaches to reduce reliance on NH care (Urtamo et al., 2019). Aging research must also focus on interventions to prevent frailty and decline, to help older adults maintain optimal functionality and a level of everyday competence for independent or minimally supported living in quasi-independent, congregate, and assisted living settings (Convergence, 2020).

Changes to Research Infrastructure

As public health expands in response to the pandemic, a focus on geriatric public health is needed (Wigginton et al., 2020). To meet the needs for quality care for older adults, research scientists and investigators who are focused on this population should be developing and implementing solutions. Funding from the National Institutes of Health is required for research to improve aging care and produce the next generation of gerontologists.

Research processes and the development of new experts must also address the transition from in-person to remote research and overcome restricted access that severely hampered research in NHs during the pandemic. Investigative teams conducting research in LTSS must build on progress in remote conduct of research initiated during the pandemic that also addresses barriers to remote participation in research for older adults (Bertuzzi & Dirita, 2021; Radecki & Schonfeld, 2020; Tugend, 2021). Although remote research teams may increase distance collaborations and the number of interdisciplinary teams, research is needed to determine best practices for socializing junior investigators into these teams. NHs and other LTSS also need to endorse and incorporate research and implementation science in these healthcare settings. Including researchers on the clinical team at the point of care has potential to not only efficiently identify needs and design research to improve care, but also facilitate implementation of research evidence by members of the LTSS culture. Cross-training of clinicians in research skills and including those with research expertise on staff may be essential for ongoing improvement in aging care quality across care settings. The crisis of the COVID-19 pandemic provides a wake-up call with new impetus and direction to overcome old and new challenges to provide quality NH care.

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What's Past Is Prologue: A Research Response to a Pandemic Tempest

Peter K. Dorhout
Vice President for Research
Iowa State University
dorhout@iastate.edu
https://orcid.org/0000-0002-7862-3270

January 2020 began like most winter months had before—cold and windy in Manhattan, Kansas. Our team of partner universities known collectively as CERES (the Coalition for Epi Response, Engagement, and Science)[1] was planning its spring advocacy meeting for late February 2020 in Washington, DC, and had secured Sen. Pat Roberts (R-KS) and USDA Undersecretary for Marketing and Regulatory Programs Greg Ibach for an afternoon meeting session on "Agricultural Biosecurity-Linking Science, Innovation, and Action." Particular attention was being paid to an emerging zoonotic disease threat in Asia, which was a new variant of Sudden Acute Respiratory Syndrome, or SARS, known as SARS-CoV-2. Its predecessor, the 2002 respiratory virus, SARS-CoV-1, is a coronavirus family virus that had emerged in China and had originated in palm civets with a disease reservoir likely in bats.[2]

It is the mission of CERES to protect and defend the agricultural industry against global threats, to respond to and recover from outbreaks, and to provide innovations for food security. Advocacy had begun by CERES in 2018 for USDA and the Department of Homeland Security to consider a land-grant university effort to address agricultural biosecurity: "Lincoln's Biodefense Strategy: Protecting the Agricultural Base."[3] The advocacy meeting on February 25, 2020, began with a typical fanfare of introductions to the topic of agriculture biosecurity, particularly zoonotic diseases affecting livestock. Nevertheless, by this date, over 130 cases of the disease caused by SARS-CoV-2, called COVID-19, had been confirmed in the U.S., and within a year, that number would exceed 28 million cases.[4] No other infectious disease had accelerated to such infection numbers since the H1N1 influenza outbreak a little more than a century before.[5]

I was offered the opportunity to provide the introductory remarks to just over 75 scientists, federal officials, and their staff in attendance for the advocacy meeting. In my introductory remarks,[6] I noted that we were standing on the shore, watching the tempest approach:

"We have gathered here today to share and learn about the current and future challenges associated with keeping American – and global – food supplies safe, reliable, and plentiful. Although the economies of the world are intricately tied through global trade and supply, global peace and stability are connected to the most fundamental of all human needs: to be fed and to be healthy. Governmental policies are enacted to strengthen the binds that tie our investments and strategies to peace and stability, and it is through government and private sector investments in fundamental new discoveries and inventions that we, the scientists in the room, will provide new methodologies, reliable technologies, and advanced countermeasures to achieve those ends.

"Before CERES was a Coalition for Epi Response, Engagement, and Science, she was the Roman Goddess of Grain. If you studied Roman or Greek mythology, you know that the Gods were servant Gods, charged to ensure humans would survive and thrive, with appropriate due reverence and fealty, of course. To accomplish this, Ceres realized that she needed to cooperate with the other Gods and Goddesses – sun, rain, seasons, and so forth – to deliver her charge to provide ample grains for a growing and thriving population.

"Our CERES today recognizes the same: to deliver on agricultural bio-security, we must collaborate and connect our talents in science and innovation that lead to action. Today, we are here to share our progress on our mission and to express the continued need to muster our forces, maybe even collaborate with the Greek God Ares to not only prepare for but to wage war on plant, animal, and zoonotic infectious diseases that threaten our very existence.

"I am an Eagle Scout. While in Scouting, I learned the importance of servant leadership. One summer, at the age of 14, I helped to lead a group of other young men on a two-week trek through the mountainous wilderness of New Mexico – the other Scouts in the room will recognize the high adventure base, Philmont. I had learned the critical skills necessary to survive – camping, hiking, and orienteering – that gave me the credibility to lead. I was a skilled map reader, and I've been intrigued with maps ever since. They show us the way. The maps of the ancient world still fascinate me.

"Roman, Greek, and Chinese explorers, among others, charted the great unknowns. Those unexplored parts on the ancient maps were often denoted with ominous markings – jagged mountains, dark jungles, violent stormy seas, and statements like 'here there be dragons.' Warnings about the terrible unknowns; harbingers of things to come; places where plagues were known to exist; places from which ill-prepared explorers never returned. Places where the tempest may deposit us. Places where the Gods feared to tread. Here there be dragons!

"We are at a critical crossroads today as we chart our course through time. With more than three times the population today on earth than were alive when I was born six decades ago, peace and prosperity across the human species are menaced by food, animal and human diseases and losses. Rapidly evolving viruses and other zoonotic pathogens threaten our production plants and animals and our own species – here there be dragons. Uncoordinated responses that are reactive and not proactive confirm the philosophers' rule that history shows again and again how nature points out the folly of man. I hope we are not witnessing the prologue."

Within 3 weeks of the CERES advocacy meeting, the number of cases in the U.S. had increased over 200 times, and universities were bracing for the storm, preparing to shut down all operations, including research, in an effort to decrease the number of infections and the rising hospitalizations and death counts. Even as these events unfolded, new evaluations were taking place to understand the unique genetic composition of SARS-CoV-2 and its unexplained virulence.[7] Moreover, given the nature of the Coro-

navirus, a virus whose genetic information is packaged in the molecular form known as *RiboNucleic Acid*, or RNA, it was astonishing that a vaccine candidate that was based on a relatively new form of vaccinology that first showed efficacy in 1990,[8] entered Phase 1 clinical trials in mid-March 2020.[9] In the long history of our knowledge of viruses, beginning with the tobacco mosaic virus in 1892,[10] there has never been such a rapid response to an infectious invader.

In Shakespeare's *The Tempest*, characters Antonio and Sebastian are contemplating their fate – to commit murder – an act that was rationalized by all that had come before, speaks Antonio,

> "And by that destiny to perform an act whereof what's past is prologue, what to come in yours and my discharge."

That their history determined their fate, and not their decisions and choices to come, suggests that the past events form the prologue for Shakespeare's story. The title of this paper suggests that, as in *The Tempest*, our past experiences with global pandemics in the 20th century [1918 Influenza (H1N1), 1957 "Asian flu" (H2N2), 1983 Acquired Immune Deficiency Syndrome (HIV)] are perhaps a prologue of the next act in infectious diseases. Just as Antonio and Sebastian had choices, so we do as well.

Here, I turn back the clock on discoveries to reveal the dilemma of 1918. Although discovered by Antonie von Leeuwenhoek in 1676, the nature of bacteria and their connection to fermentation (Louis Pasteur) and disease (Robert Koch) would not be made until the late 19th century, during what was known as "The Great Sanitary Awakening."[11] At this time, the average life expectancy in the U.S. was fewer than 40 years (Figure 1, page 4).[12] Joseph Lister (yes, he invented Listerine) recognized the importance of sanitized hands and equipment in medical procedures. In Berlin, Koch studied numerous 19th-century pandemic diseases, including cholera and anthrax, and became the father of medical bacteriology, the germ theory of diseases, Koch's postulates, and public health. He developed a potential treatment for tuberculosis, for which he was awarded only the third Nobel Prize in medicine, and life expectancies began to turn higher. Bacteria and bacteriology would play an important role in the prologue to the 1918 influenza pandemic.[5]

As Fig. 1 illustrates, the average life expectancy for the latter half of the 19th century was essentially flat, with the exception of the mid-1860s and the impact of the Civil War, around 40 years (point 1). The lessons from "The Great Sanitary Awakening" led to a steady climb in longevity, primarily from improved infant mortality rates, which were as high as 20% into the early 20th century in the U.S. Improved working conditions in factories, the introduction of the electrostatic precipitator in coal fired furnaces and power plants,[13] and a migration of the population from rural to urban living helped to improve public health overall; however, this latter point would prove to be a significant challenge for disease control in the crowded cities in the U.S. and elsewhere. Notable deviations from the steady increase in longevity included the 1918 H1N1 influenza pandemic (point 2) and the effective end to childhood infectious diseases such as measles and polio (point 3) offset by the factors of smoking and the impact of cancers, heart disease, and unbalanced diets and lifestyle; although, all of these have been the focus of NIH funding in recent decades.

Bacteriology may have been the prologue to the 1918 pandemic, but it also

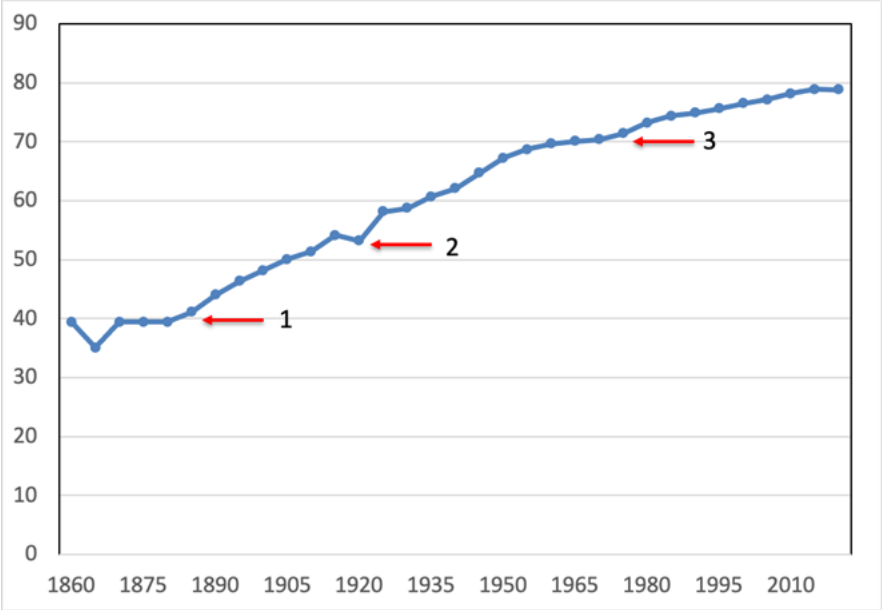

Figure 1. Life expectancy in years in the U. S. 1860-2020

created a tempest within the medical community as scientists attempted to understand the nature of the outbreak and how to best treat it. Bacteria under study in living organisms were determined to be "filterable" by removing bacteria from a solution of fluids taken from a diseased patient through culture treatment and filtration through a porcelain filter, in some cases yielding a "poisonous fluid" that contained a "disease" agent.[14] The term "virus" comes from the Latin term for poison since the virus passed through into the poisonous filtrate. Viruses may also act as parasites in bacteria or protozoa and may not pass the "filtration" test; nevertheless, the work in Pasteur's lab (and later the Institute) would be influential in establishing some of the most significant treatments for diseases, such as rabies and diphtheria. As an aside, it is the study of viral infections of bacteria, and the ability of bacteria to "inoculate" its offspring to that virus, that led to the 2020 Nobel Prize in chemistry for the discovery of the CRISPR Cas9 process for gene editing by Charpentier and Doudna.[15]

At the time of the 1918 influenza outbreak, a new generation of bacteriologists and virologists was emerging from European and U.S. research universities; although the group would remain relatively small for another few decades. The past, for these researchers, was the rudimentary understanding of bacteria (microscopic) and viruses (in the filtrate and sub-microscopic, at that time). The studies of the earliest Nobel Laureates in medicine, together with the relatively new institutes in the U.S. (and the creation of the Marine Health Service, the prologue to the National Institutes of Health), were important foundations for relatively new scientists such as Oswald Avery and later Gertrude Elion, who would struggle with influenza and its viral mysteries but would discover new realms of science through their scientific choices.

Avery, who spent the 1918 pandemic collecting, isolating, and growing a bacterium called *Bacillus influenza*, noted that not all influenza patients had this mystery bacterium in their systems and that the filtrate from tissue "swabbing" could

infect rabbits and other patients. Nevertheless, he pursued the *B. influenza* bacterium theory until the virus was isolated in 1930. Avery remained convinced that the symptoms of influenza, such as pneumonia, were caused by a bacterium, and he continued to study *pneumococcus* at the Rockefeller Institute in New York where he isolated two strains, R and S, the latter of which had a protein "capsule" that acted like a shell, and it was the virulent bacillus. By transferring some cellular material from S to the R strain, he could cause the R to grow a shell. He deduced that this cellular material must contain information that could cause one strain to grow into another: he had discovered the function of DNA.[16] Moreover, his work on a pneumonia vaccine formed the basis for the current pneumonia vaccine, and his discoveries related to the function of DNA led to the pursuit of the structure by Francis Watson and James Crick, which led to their Nobel Prize in 1962.

The chemical building blocks for DNA are nucleic acids. Two nucleic acids are built from the chemical building block purine, adenine and guanine (or A and G for shorthand notation), which bind to two other nucleic acids, cytosine and thymine (C and T). A-T and C-G form "base pairs" that bind two strands of nucleic acids together to form the structure of DNA. The chemical class of purine compounds is extensive, and Gertrude Elion, a chemist at Burroughs-Wellcome in New York who was born on the eve of the 1918 influenza pandemic, would elucidate an important family of chemical compounds from purines that impacted how DNA could be interpreted by cellular components and ultimately how DNA could be rendered impotent. Her creative work led to antiviral and anticancer agents based on purines, including azidothymidine, AZT,[17] that earned her the Nobel Prize in 1988. One of the current COVID-19 treatments involves the broad-spectrum antiviral medication Remdesivir, which is built from Elion's purine chemical framework.

These contributions represent examples of how research from the past serves as prologue to the "current present": from the early discoveries of bacteria and viruses and the state of medical understanding in the 19th century to the challenges of responding to and managing a pandemic in 1918 and beyond. Avery and Elion are just two examples from this past century of chemical/biological research since the 1918 pandemic that illustrate how lessons learned from the past emerged into some of the most influential medical discoveries of the present, including treatments for the current SARS-CoV-2 virus.

There have been a few lessons learned this past century through many tempests of research. Emerging from the influenza pandemic of 1918, the Marine Health Services would become the National Institute(s) of Health in 1930. Since that time, the Federal investment in research with the NIH has totaled roughly $1 trillion; the total financial loss and cost of recovery from the COVID-19 pandemic was estimated at $16 trillion.[18] Investments in fundamental science, which led in the past to new chemical and biological techniques that enabled us to unravel the genomes of humans and other organisms, will continue to shine a light on the diversity of pathogens we may confront and how to do battle with them. Fundamental research led to the discovery of messenger RNA (mRNA) and its role in developing vaccines against RNA viruses, which enabled us to spool up vaccine candidates within a matter of weeks following the sequencing of the SARS-CoV-2 genetic code. If the past is prologue for the next

century of discoveries, then surely we are on the brink of some wonderful things.

For those wonderful things to be realized, there are still challenges ahead for the global research enterprise. Funding is only part of the formula. In the U.S., there remain significant differences among communities of people who have access to medical treatments, let alone to education and participation in the discovery process. The 2019-2021 pandemic has revealed significant inequities in access, and it is incumbent upon the leadership in higher education to respond to those inequities of access to education and discovery by creating environments of inclusion and belonging for those from backgrounds that are different from the majority. The stories of post-1918 pandemic discoveries are peppered with inequities between men and women, "national" and "international," and white and non-white scientists.[5] The past should not write the prologue for our diversity and inclusion efforts; in particular, this quote from John Dewey in *The New Republic* from 1934 is telling:

> "Those who contend that intelligence is capable of exercising a significant role in social affairs and that it would be well if it had a much larger influence in directing social affairs can readily be made to appear ridiculous. From the standpoint of past human history it not only appears but is ridiculous. It takes little acquaintance with the past to realize what the forces have been that have determined social institutions, arrangements and changes. There has been oligarchical despotic power, political, ecclesiastic and economic, sometimes exercised openly, more often by all sorts of indirect and subtle means. Habit, custom and tradition have had a weight in comparison with which that of intelligence is feeble. Custom and tradition have originated in all sorts of ways, many of them accidental. But, once established, they have had weight independent of the conditions of their origin and have reinforced the power of vested interests. At critical times, widespread illusions, generated by intense emotions, have played a role in comparison with which the influence of intelligence is negligible."[19]

More modern perspectives suggest that change is possible; however, Dewey isn't far off in recognizing that culture can eat strategy for lunch. Fiona Murray wrote in *Science* that by studying inventors and inventions of products for women, female inventors made significantly improved products for women.[20] The future of invention and innovation, which improves ideas and products for all, must include diversity of thought. We must continually examine our teams and inputs and ask, "Who or what is missing?" from our innovation. Different perspectives, views, and experiences need to be part of our scientific lexicon, because changing the culture takes many steps and a lot of time.

I will conclude with another viewpoint from *The Tempest*; a passage that may be more uplifting than that of Antonio and Sebastian contemplating murder or John Dewey arguing that intelligent strategies for change are ridiculous. A passage that suggests that the prologue of tomorrow may be written by our willingness to improve today:

> "O wonder!
> How many goodly creatures there are here!
> How beauteous mankind is!
> O brave new world,
> That has such people in't!"
> - Miranda, *The Tempest* (Act V. S1.)

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RETREAT PARTICIPANTS 2021

Keynote Speaker
Joseph E. Steinmetz, Executive Director, Psychological Clinical Science Accreditation System; Former Chancellor of the University of Arkansas

Iowa State University
Peter K. Dorhout, Vice President for Research

Ames Laboratory, U.S. DOE
Julienne M. Krennrich, Director, Innovation Partnerships

Kansas State University
Beth A. Montelone, Senior Associate Vice President for Research
Kimberly Kirkpatrick, University Distinguished Professor

The University of Kansas
Mabel L. Rice, Fred and Virginia Merrill Distinguished Professor of Advanced Studies Director, Merrill Advanced Studies Center
Simon Atkinson, Vice Chancellor for Research
Barbara Bichelmeyer, Provost and Executive Vice Chancellor
Samantha Ghali, Child Language Doctoral Program Doctoral Candidate
Doug Girod, Chancellor
Susan Lunte, Ralph N. Adams Professor of Chemistry and Pharmaceutical Chemistry
Sally L. Maliski, Dean and Endowed Professor in Oncology Nursing
Karina Saechao, Child Language Doctoral Program Doctoral Candidate
Dale Slusser, Associate Vice President, Development
Kristine Williams, E. Jean Hill Professor, KU School of Nursing

University of Missouri-Columbia
Richard J. Barohn, Executive Vice Chancellor for Health Affairs

University of Nebraska-Lincoln
John P. Carroll, Professor and Director, School of Natural Resources
Bob Wilhelm, Vice Chancellor for Research and Economic Development

Notes