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Research Impact Under COVID-19

FINANCIAL CRISIS AND THE "PANDEMIC NORMAL"

Research output has been severely impacted during the COVID-19 pandemic, at home and abroad. The Research Impact Metric (RIM) Model is a novel tool that estimates the impact. The United States is the global leader in research—however, as the financial impact to research approaches the tens of billions of dollars and our global leadership in research is threatened, national security and economic stability are jeopardized. What started as an acute occurrence has become a chronic crisis, and will persist until an effective vaccine is widely available. As we learn to do research under the "Pandemic Normal," a new commitment by Federal leaders, Research institutions, and other stakeholders is imperative.

Released August 25, 2020

Research Impact under COVID-19: Financial Crisis and the "Pandemic Normal"

EXECUTIVE SUMMARY

The COVID-19 pandemic and the subsequent economic downturn have led the country into unprecedented times—consequently, an unprecedented response is needed to safeguard research and development at colleges, universities, and research organizations across the United States. ***This paper presents a model for estimating research output loss and financial impact, describes the challenges of doing research under the new "Pandemic Normal," and advocates for renewed commitment and a substantial infusion of new research investment. Federal leaders, research institutions, and all stakeholders must rally around the longstanding Federal Government-Research Institution Partnership.***

- The Research Impact Metric (RIM) Model is a novel model that estimates the research output loss and financial impact due to the COVID-19 pandemic and the resultant economic downturn. The initial ramp down, the transition to ramp up, and the uncertainty going forward, have had a dramatic impact on research.

- The RIM model provides important data on the research output loss and financial impact at mission diverse and geographically widespread institutions. The RIM model has shown: 1) research output losses between 20 and 40 percent, 2) financial disinvestment impact in the hundreds of millions of dollars at individual institutions, and 3) potential impact in the tens of billions of dollars across the entire U.S. research enterprise. Without new and sustained investment, our institutions' and the nation's research capabilities will be severely weakened.

- Just as importantly, we are at risk of losing a whole cohort of graduate and post-doctoral students seeking training and education at research institutions across the U.S. They are our future scientists, engineers, and innovators, and include researchers from

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The Council on Governmental Relations (COGR), established in 1948, is an association of almost 200 leading universities and research institutions and is nationally recognized as the technical expert on a wide range of research policy issues, including how the research funding model works in the United States. For more information on COGR, please visit www.cogr.edu

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underrepresented groups, minorities, women, and junior researchers.

- A new "Pandemic Normal" for how research is conducted in our country, as well as globally, has emerged—and inefficiencies are unavoidable. For example, the scope of research promised on a $1 million award (pre-COVID-19) will now require more than $1 million to complete. And, the scope of research to be delivered in one year (pre-COVID-19) will now require more than one year. In order to operate effectively and efficiently under the "Pandemic Normal," new measures such as redefining proposal and budgeting guidelines, eliminating overly-burdensome regulations, and related measures are necessary.

- Understanding the impact and supporting the research enterprise to get through this crisis is paramount to maintaining the global competitiveness, technological leadership, and the economy of the United States.

This paper draws on the expertise and experience of the COGR membership and describes research impact under COVID-19 in the following sections:

- **PART I. INTRODUCTION.** Sets the stage and defines the crisis, including threats to the research enterprise (see page 5).

- **PART II. THE RESEARCH IMPACT METRIC (RIM) MODEL.** Presents key considerations and assumptions, which can be used by institutions to assess/estimate the research impact at an institution, and by others to understand the breadth and depth of impact of the pandemic to the research mission across the country and globally.

- **PART III. THE PANDEMIC NORMAL.** Presents a cautionary tale of how the research community and stakeholders should expect research to unfold until there is a widely available vaccine that allows life to return to normal. Under a "Pandemic Normal," where physical laboratory access, social distancing, and other new norms around research operations are implemented, the repercussions will be seen in research delivery, program goals and aims, and realistic expectations around research outcomes.

- **PART IV. CASE STUDIES.** Five case studies are presented. These are representative of five diverse research institutions—two privates and three publics, three of which have medical schools, one that is a land-grant institution, and one that has both a medical school and is a land-grant. ***These case studies demonstrate that the research output loss and financial impact are real and severe.***

- **PART V. CONCLUSION.** Final thoughts including the need to fully engage the Federal Government-Research Institution Partnership.

- **CONTRIBUTORS AND APPENDICES.** Key Contributors, How Research Operations are Disrupted (Appendix A), and Research Under the Pandemic – Challenges and Adaptations (Appendix B).

- **ADDITIONAL RESOURCES.** COGR resources specific to COVID-19's Impact to Research, including a dedicated web page, agency policy links, FAQs, and more.

PART I. INTRODUCTION

These are unprecedented times. The impact on the research function at research institutions since March 2020 is real, material, and in many cases, severe. Ramp up initiatives are ongoing, but the effort to return to normal functioning has been uneven and the risk of setbacks lurks as the impacts of COVID-19 continue to persist.

This paper introduces a Research Impact Metric (RIM) Model as a tool to demonstrate the impact on research output due to the COVID-19 pandemic for the period March 2020 through February 2021.

The RIM Model can be used as an internal tool to estimate the impact at an institution and also may be used to understand the macro-impact of COVID-19 on the United States' research enterprise. As the disruptions caused by the COVID-19 pandemic persist, ***it is apparent this is causing a net disinvestment in research and development activities in the United States—in effect, requiring new and significant capital investments to ensure the research enterprise is not irreversibly disrupted.*** Should this investment be forthcoming, the United States can have confidence in its ability to retain its position as the global leader in innovation and discovery.

Institutions are confronted with difficult decisions caused by the COVID-19 pandemic and the subsequent economic downturn. Cost cutting measures are under consideration and being implemented across all functions of research institutions, and difficult decisions rest on institutional policies and federal and state guidance, rules, and regulations. All institutions are impacted economically by the response to COVID-19—public and private, medical and non-medical, rural and urban.

The threats to the United States research enterprise are real and include:

- Inability to achieve original program goals
- Loss of entire research programs
- Loss of the ability for investigators to collaborate across institutions, designated research centers, federal laboratories, and via traditional subrecipient agreements
- Loss of a generation of trained scientists and engineers, as well as researchers in social, behavioral, education disciplines, and the arts—all of whom provide a workforce and education pipeline to meet the needs of academia, government, and industry
- Loss of foreign students and scholars and their major contributions to academia
- Significant slowdowns in discoveries and technological development
- Recurring costs of the "ramp down, ramp up, ramp down" cycle
- Loss of cell lines, animal colonies, and continuity of human subjects trials
- Disruptions in core facilities and centers due to interrupted research
- Fear of the unknown, including loss of employee morale and the persistent uncertainty about current and future employment
- And ultimately, the decrease, not only in volume, but also the quality of research conducted in the United States

The federal government has recognized these threats. For example, the Office of Management and Budget, in collaboration with federal agencies, provided administrative and salary charging flexibilities to protect against furloughs and layoffs that could prevent a quick return to normal research activity.[1] ***However, until the COVID-19 pandemic is definitively controlled, the possibility of shuttering research laboratories and research activity could become a reality.*** The threat of a severely damaged research enterprise should be addressed while there is time to mitigate it by allowing the research function to operate at maximum efficiency and effectiveness under its unique "Pandemic Normal."

[1] *See the March 19 release of OMB M-20-17 "Administrative Relief for Recipients and Applicants of Federal Financial Assistance Directly Impacted by the Novel Coronavirus (COVID-19) due to Loss of Operations" and the June 18 release of OMB M-20-26 "Extension of Administrative Relief for Recipients and Applicants of Federal Financial Assistance Directly Impacted by the Novel Coronavirus (COVID-19) due to Loss of Operations."*

PART II. THE RESEARCH IMPACT METRIC (RIM) MODEL

The Research Impact Metric (RIM) is a model designed to illustrate the degree to which research output (as a percentage) has been negatively affected under the COVID-19 pandemic. The RIM also captures financial impact, or disinvestment, expressed in dollars.

Research Output Loss =

Research Output Loss due to COVID-19 Emergency Restrictions

divided by:

Research Output under Pre-COVID-19 (Normal) Conditions

For example, a 30 percent loss indicates that 30 percent of research output is in jeopardy, which means certain program goals and aims may not be achievable in the scheduled time frame—and unless addressed systematically, this 30 percent becomes a permanent loss of research output and productivity. Note, the COVID-19 pandemic has not halted all research, as investigators, research personnel, and institutional leaders have taken significant measures to keep the research engine functioning by maintaining/preserving the most critical and irreplaceable elements.

Despite these heroic efforts, NIH Director Francis Collins, while testifying before Congress on May 7, 2020 stated: "*The estimates are something like $10 billion of NIH funded-research that is going to disappear because of the way in which this virus has affected everybody requiring this kind of distancing and sending people home."*[2] With financial and other pressures on higher education institutions, it is inevitable that output has been and will continue to be lost as the COVID-19 pandemic makes it impossible for research to function according to traditional standards**.**

The RIM Model presented in this paper captures research impact for all externally sponsored research at the institution. ***However, it can be adapted to a range of disciplines to differentiate between biochemistry, aerospace engineering, computer science, literature/language, and other disciplines.***

[2] *See "Virus Will Cost NIH $10 Billion in Lost Research, Director Warns (1)" (Bloomberg Law) – May 7, 2020*

In addition, the model also treats all types of expense categories the same. For example, labor, laboratory supplies, and travel all are assumed to be affected similarly. However, we know the impact on labor and the impact on travel caused by the COVID-19 pandemic are very different—labor continues to be productive at various levels, while the ability to travel has been significantly impaired. ***Though we treat each expense category the same, the model can be adapted to provide differential treatment for various expense categories.***

Other assumptions of the RIM Model include:

- The starting point is the "average" month of financial expenditures for federal and other sponsored research at the institution (Chart A.), prior to the COVID-19 pandemic. This simplifies the model, though more precision (e.g., academic year, summer months, specific expense categories) could be used to determine monthly financial expenditures.
- Four "Negative Impact" scenarios are used: 10 percent, 25 percent, 50 percent, and 80 percent, with 10 percent being the minimal and 80 percent being the most severe. These scenarios are flexible and can be adjusted according to lab circumstances and safety policies and procedures in place at the institution.
- The model also is meant to takes into account costs such as cell lines, animal colonies, and human subject participation, which all have been interrupted and result in a real impact on research outcomes. Also included in the model are losses to core facilities.
- Negative impact is based on currently available information, which includes an estimated duration of lab closures to varying degrees that began in March, continued into May and longer, and will persist to varying degrees as institutions continue to ramp up research and work to implement new standards for doing research under COVID-19.

We have taken the high-level approach, which we suggest presents a fair and representative RIM Model for the entire institution. However, the "hypothetical model" presented below could be completed for specific academic disciplines (biochemistry, aerospace engineering, computer science, literature/language, etc.) with differentiated impacts for various expense categories (labor, travel, etc.). The approach taken depends on the needs of the institution—the "hypothetical model" is meant to be an instructive starting point. Actual case studies use the high-level approach and are shown in Part IV.

HYPOTHETICAL INSTITUTION:

Chart A. is premised on Pre-COVID-19 (i.e., FY 2019) average monthly federal and other sponsored research expenditures, by categories of expense (note, including categories of expense is optional)—***most important is to arrive at monthly expenditures.*** The negative impact scenarios are 10 percent (minimal), 25 percent, 50 percent, and 80 percent (most severe).

Chart A. Monthly Negative Impact on Research using Various Scenarios

	Pre-COVID Monthly (millions)	10% Negative Impact	25% Negative Impact	50% Negative Impact	80% Negative Impact
Payroll & Fringe Benefits	20.0	2.0	5.0	10.0	16.0
F&A Reimbursement	10.0	1.0	2.5	5.0	8.0
Subrecipient Payments	7.0	0.7	1.8	3.5	5.6
Other Costs	1.0	0.1	0.3	0.5	0.8
Lab Supplies	1.0	0.1	0.3	0.5	0.8
Recharges	1.0	0.1	0.3	0.5	0.8
FinAid/Tuition Remission	1.0	0.1	0.3	0.5	0.8
Professional Services	0.1	-	-	-	0.1
Capital Equipment	1.0	0.1	0.3	0.5	0.8
Travel	0.2	-	-	0.1	0.1
MONTHLY (millions)	**$42.3**	**$4.2**	**$10.6**	**$21.2**	**$33.8**
ANNUAL (millions)	**$507.6**	**$50.4**	**$127.2**	**$254.4**	**$405.6**

In this hypothetical, the institution has average monthly research expenditures (federal and other sponsored) of $42.3 million, and annual expenditures of $507.6 million. For example, using a 25 percent negative impact for the entire year, the negative impact would be $10.6 million monthly and $127.2 million for the entire year.

In Chart B. below, the negative impact scenarios are entered on a month-by-month basis to model both the known negative impact (e.g., March thru July 2020) and the projected impact going forward (e.g., August 2020 thru February 2021). While Chart B. stops at February 2021, it is becoming increasingly clear that research performance will likely be impacted for much longer.

The results in Chart B. are shown both in terms of dollars and percentage. ***The RIM Model calculation demonstrates the research output that has been lost—program goals and aims may not be achievable in the scheduled time frame, or the research may be lost altogether. Unless addressed systematically, this becomes a permanent and irreplaceable loss of research. This critical loss to the continuity of research, ultimately impacts future scientific research workforce development.***

Model #1 in Chart B. presents "Continuous Ramp Up" where there is no significant recurrence of COVID-19 affecting the institution. Model #2 presents "Interrupted Ramp Up" where there is disruption, for example, in November due to a recurrence of COVID-19 affecting the institution. The one-year negative impact to research covers March 2020 through February 2021.

Chart B. Research Impact Metric (RIM) Calculation
Model #1 – Continuous Ramp Up (no significant recurrence of COVID-19)

Month	Negative Impact	10% Negative Impact	25% Negative Impact	50% Negative Impact	80% Negative Impact
March 2020	$21.2			$21.2	
April 2020	$33.8				$33.8
May 2020	$33.8				$33.8
June 2020	$21.2			$21.2	
July 2020	$21.2			$21.2	
August 2020*	$10.6		$10.6		
September 2020*	$4.2	$4.2			
October 2020*	$4.2	$4.2			
November 2020*	$4.2	$4.2			
December 2020*	$4.2	$4.2			
January 2021*	$4.2	$4.2			
February 2021*	$4.2	$4.2			
Disinvestment	**$167.0 M**				
Research O/P Loss	**32.9%**				

Research Output Loss = $167.0 M / $507.6 M (annual amount) = 32.9%

**March-July 2020: Actuals. August 2020-February 2020: Projections.*

Chart B. Research Impact Metric (RIM) Calculation
Model #2 – Interrupted Ramp Up (recurrence of COVID-19 in November)

Month	Negative Impact	10% Negative Impact	25% Negative Impact	50% Negative Impact	80% Negative Impact
March 2020	$21.2			$21.2	
April 2020	$33.8				$33.8
May 2020	$33.8				$33.8
June 2020	$21.2			$21.2	
July 2020	$21.2			$21.2	
August 2020*	$10.6		$10.6		
September 2020*	$4.2	$4.2			
October 2020*	$4.2	$4.2			
November 2020*	$10.6		$10.6		
December 2020*	$21.2			$21.2	
January 2021*	$21.2			$21.2	
February 2021*	$10.6		$10.6		
Disinvestment	**$213.8 M**				
Research O/P Loss	**42.1%**				

Research Output Loss = $213.8 M / $507.6 M (annual amount) = 42.1%

**March-July 2020: Actuals. August 2020-February 2020: Projections.*

Different approaches may be used for estimating impact, and each approach will be institution-specific. Other methods for estimating impact include surveys to measure campus/facility/lab access, percent of personnel (e.g., faculty, graduate students, post-docs, research scientists) allowed to access facilities (including the time and duration of their access), or a variations on these types of surveys. Most important is to develop sound institutional metrics that demonstrate how research has been impacted by the COVID-19 pandemic.

In summary, the projected annual loss to research output for this hypothetical institution is devastating:

Research Output Loss and Financial Disinvestment
(March 2020 thru February 2021)

Annual Research (external)		Output loss (Continuous Ramp Up)	Disinvestment (Continuous Ramp Up)		Output loss (Interrupted Ramp Up)	Disinvestment (Interrupted Ramp Up)
$507 M		**32.9 %**	**$167 M**		**42.1 %**	**$214 M**

The RIM is demonstrated both by the research output loss (between 32.9 and 42.1 percent) and the financial disinvestment (between $167 and $214 million)—***these numbers are alarming for an institutional already reeling from real revenue losses in tuition, state funding, athletics revenue, and housing, food services, and other revenues.***

In addition, we are at risk of losing a whole cohort of graduate and post-doctoral students seeking training and education at research institutions across the U.S. They are our future scientists, engineers, innovators, and include researchers from underrepresented groups, minorities, women, and junior researchers. This would be a devastating loss, and one the nation cannot tolerate. Case Studies are shown in Part IV.

III. THE PANDEMIC NORMAL

While productive and important research has been and will continue to be performed during the COVID-19 pandemic, the initial shutdown of research labs, uneven reopening, implementation of new mandated safety practices, research dependencies through subawards with collaborators who are at different phases of ability to work, and risk of future shutdowns all have contributed to hindering research performance according to traditional standards of efficiency and effectiveness. Approaches such as the RIM Model provide useful quantitative metrics to show the impact to research.

It is understood that, given the unprecedented nature of the COVID-19 pandemic, estimates of research output loss are just that, estimates, which are institution-specific. Still, it is imperative that the research community and policymakers understand the gravity of the situation. In addition

to the RIM Model, institutional surveys can be used to collect data to more fully assess the impact on research. For example, surveys can be conducted on campus/facility/lab access; the percent of personnel (e.g., faculty, graduate students, post-doc / research scientist) allowed to access facilities, including the time and duration of their access; impact on specific populations and how these populations may be disproportionately impacted (i.e., minorities, women, and other under-represented populations), as well as other indicators that can help demonstrate the impact on research.

All of this leads to a discussion of the Pandemic Normal, requiring recognition that how we conduct research is significantly changed, and will be the norm, at least until an effective vaccine is widely available.

What is meant by a "Pandemic Normal" for an institution?

First, with significant projected loss in research output, without both time extensions and funding supplements to recover the loss in research output, most research projects will be unable to meet their original program goals and aims. Scopes of work can be adjusted, retro-actively, and the research that can be completed still provides value and advances the body of knowledge. However, there will be other consequences as well. The careers of academic personnel (faculty, graduate students, post-docs) and at-risk populations (minorities, women, and other under-represented populations) that rely on the outcomes of research (peer-reviewed publications, dissertations) will be negatively impacted.[3] The discovery and development of technologies may be delayed. The research community and all stakeholders must be realistic and holistic in assessing the risk to the country in terms of lost research, loss of innovation and discoveries that emerge from research, and ultimately, loss of global competitive advantage.

Second, until the COVID-19 pandemic is definitively controlled, the research community, stakeholders, and the country as a whole must come to terms with the fact that there is a "Pandemic Normal" as it relates to conducting research. In the simplest terms: The scope of research promised on a $1 million award (pre-COVID-19) will now require more than $1 million to complete. And, the scope of research to be delivered in one year (pre-COVID-19) will now require more than one year.[4]

[3] *See "The career cost of COVID-19 to female researchers, and how science should respond" (Nature)* https://www.nature.com/articles/d41586-020-02183-x *and "'It's like we're going back 30 years': how the coronavirus is gutting diversity in science" (Nature)* https://www.nature.com/articles/d41586-020-02288-3

[4] *See Congressional Research Service Report "Effects of COVID-19 on the Federal Research and Development Enterprise"* https://crsreports.congress.gov/product/pdf/R/R46309

New standards of research operations will define the Pandemic Normal

These standards include but are not limited to:

- Restricted access to research buildings and research laboratories
- Social distancing within the laboratory
- Staggered shift-scheduling (i.e., 6:00 AM-2:00PM, 2:00 PM-8:00 PM, etc.), and the loss of intellectual stimulation and sharing that comes from working collaboratively
- Additional "down-time" to clean between shifts (and between equipment use cycles) requiring research personnel to clean the space (and equipment) to be in compliance with CDC guidelines
- Adjustment to working with continuous use of PPE where formerly not necessary, along with the associated inefficiencies and costs
- Temporary (or permanent) loss of research personnel who test positive or display COVID-19 symptoms
- Deployment of new health and administrative staff to implement testing and contact tracing, as well as to assure research laboratory compliance with safety policies
- Transition to remote work if a research building or laboratory is shut down
- New and unanticipated day-to-day work disruptions affecting research operations
- Slow or compromised supply chains and associated higher costs
- Reduced lab visitors from visiting scholars and collaborators
- Interruption of or limitations on conducting in-person human subject research
- Discontinuation of conducting artistic and performing arts exhibition with live audiences

These are only a few examples. ***APPENDIX A, HOW RESEARCH OPERATIONS ARE DISRUPTED*** provides additional examples to the above list, and ***APPENDIX B, RESEARCH UNDER THE PANDEMIC – CHALLENGES AND ADAPTATIONS,*** provides real life examples of how specific research projects, across various academic disciplines, have been impacted under the Pandemic Normal.

The Pandemic Normal requires the research community, and importantly, ***the research funding agencies,*** to rethink how research continues under the Pandemic Normal—and consequently, the monetization of unavoidable inefficiencies which must be captured in evaluating and funding new proposals, both in the scope of work and budgets submitted to the funding agencies.

Proposals, in fact, may also need to include an approximate and well justified "contingency factor," recognizing the possibility that a facility may need to shut down for a period of time. Such budgeting flexibility could reflect local/regional COVID-19 conditions and would inject more certainty into the research process. If conditions do not hinder research progress, the funds would be retained by the funding agency.

As an example, the Pandemic Normal can be monetized as follows: A graduate student, who cannot readily access the lab as in the past, will take longer to complete the same work, assuming the graduate student is working in shifts and has restricted access under the Pandemic Normal. For dissertation support, typical three-year graduate student support requested on a grant may be extended by an additional semester (or semesters). Assuming a graduate student needs an additional semester for the same quantity of work, the research impact is $1/6^{th}$ or 16.7%. Additional time may also be required for field work should travel be limited or stopped all together.

Monetization of unavoidable inefficiencies also is relevant with respect to traditional ways of thinking about research infrastructure. Most of an institution's research infrastructure is captured in the Facilities and Administrative (F&A) cost rate and reimbursement.[5] This includes the costs of constructing and maintaining technologically advanced research laboratories, protecting human and animal subjects in research, safeguarding the community from dangerous chemicals and biohazard waste, ensuring reliable financial stewardship, providing high-speed data processing and technology, and supporting numerous other compliance and administrative activities that help researchers conduct their research in the least-burdensome environment possible. It is inevitable that the cost of an institution's research infrastructure will increase as long as the COVID-19 pandemic persists. Any mechanisms that can provide for recovery of these costs will offer welcome relief to research institutions.

In addition, institutional ramp down efforts (after the initial shutdown), ramp up efforts (after it was deemed safe to transition), and the possibility of additional cycles of ramp down / ramp up, each result in new costs. This includes physical modifications to labs (changes to entry points, signage, badge readers, HVAC modifications, Plexiglas barriers, etc.), PPE and sanitizing stations, regular COVID-19 testing protocols, specialized sanitization materials and procedures for sensitive laboratory equipment such as microscopes, staffing (increased security personnel, janitorial and environmental safety, other administrative personnel, etc.), and unanticipated costs that certainly be incurred. Some of these costs will be allowable as direct charges to federal awards and others will be more appropriately classified as F&A (in which case they are not

[5] *See COGR's 2019 paper, "Excellence in Research: The Funding Model, F&A Reimbursement, and Why the System Works" (see: https://www.cogr.edu/sites/default/files/ExcellenceInResearch4_12_19_0.pdf)*

recoverable as direct charges). Regardless, this also contributes to the monetization of unavoidable inefficiencies and real costs to be absorbed by the institution.

The Pandemic Normal may also be an opportunity to rethink how federal agencies and research institutions can work together to reduce regulatory burden. Program officers at federal agencies can be empowered to implement a supplement policy, review justifications on a case-by-case basis, and allow for project performance period extensions with funding to offset other inefficiencies. Since this is a systemic inefficiency, an allowance at the proposal stage (until a vaccine is available and we return to an approximation of the old normal) will be a helpful and practical solution.

Finally, one more opportunity under the Pandemic Normal would be, on a case-by-case basis, providing additional stipend support for students whose research requires an extended time period to complete the necessary work, subject to justification. In the education and social science research fields, where access to schools, field stations, or human subjects is restricted, it will be important to allow these researchers more time to complete the same quantity of work. If funding agencies adopt the target date approach for proposal submission deadlines, this would allow more flexibility should researchers face delays due to reduced facility access, graduate student availability, or illness. Allowing for more frequent deadlines can also provide enhanced flexibility and reduce burden on sponsored programs staff and avoid the need for additional personnel.

The Pandemic Normal, while making research a more expensive and challenging endeavor, provides a new opportunity to identify new practices to facilitate research and reduce regulatory burden. A joint commitment by the research funding agencies and the research institutions to implement new and needed practices and flexibilities during the Pandemic Normal would be action taken in the true spirit of the Federal Government-Research Institution Partnership.

IV. CASE STUDIES

The five case studies below, at mission diverse and geographically widespread institutions, represent real-life research institutions in the United States. Using the RIM Model, research output loss and financial disinvestment are shown for the 12-month period, March 2020 through February 2021. ***These case studies demonstrate: 1) research output losses between 20 and 40 percent, 2) financial disinvestment impact in the hundreds of millions of dollars at individual institutions, and 3) potential impact in the tens of billions of dollars across the entire U.S.***

research enterprise. Without new and sustained investment by the federal government and other research sponsors (or until an effective vaccine is found and widely distributed), our institutions' and the nation's research capabilities will be severely weakened, and these research output losses will persist.

Research Output Loss and Financial Disinvestment
(March 2020 thru February 2021)

Private/ Public	Med School	Land Grant	Annual Research	Output Loss (No Interrupt)	Financial Disinvest (No Interrupt)	Output Loss (November Interrupt)	Financial Disinvest (November Interrupt)
Private	Y		$900 M	24%	$218 M	33%	$296 M
Public	Y		$409 M	21%	$88 M	38%	$153 M
Public		Y	$150 M	23%	$34 M	41%	$61 M
Private	Y		$670 M	22%	$145 M	31%	$206 M
Public	Y	Y	$1,097 M	18%	$201 M	28%	$302 M

No Interrupt. (No significant recurrence of COVID-19)
November Interrupt. (Recurrence of COVID-19 in November)

The RIM Model presented is a macro-model spanning the medical, physical, engineering, social and behavioral sciences, and the humanities at an institution. It can be fine-tuned, depending on the needs of the institution. Regardless of how it is used, it can provide timely and important information to a diverse range of stakeholders.

V. CONCLUSION

This paper presents a model for estimating research output loss and financial impact, describes the challenges of doing research under the new "Pandemic Normal," and advocates for renewed commitment by federal leaders, research institutions, and all stakeholders to the longstanding Federal Government-Research Institution Partnership. It also raises many new questions and issues around research operations during a pandemic—including effective practices around institutional and research finances, institutional management of research

programs, and funding agency partnership and reducing regulatory burden. All are fluid topics that must be addressed regularly and in more depth under the Pandemic Normal.

What goes without saying is that an unprecedented response is needed to safeguard the United States' research enterprise and ensure that the United States remains the global leader in research, innovation, and discovery. Research output has been severely impacted under the COVID-19 pandemic and the following are required:

- A new and sustained investment in our institutions' and the nation's research capabilities is imperative. The RIM model provides important data on the research output loss and financial impact at mission diverse and geographically widespread institutions. The RIM model shows: 1) research output losses between 20 and 40 percent, 2) financial disinvestment impact in the hundreds of millions of dollars at individual institutions, and 3) potential impact in the tens of billions of dollars across the entire U.S. research enterprise.

- Recognition that without this new research investment, active projects will be unable to achieve original program goals, in some cases causing the loss of an entire research program.

- Further, without this new research investment, the country is at risk of a significant reduction in today's graduate and post-doc students, who are poised to be the next generation of the world's best scientists. Particularly at risk for being disproportionately impacted are minorities, women, and other under-represented populations.

- Acceptance of the Pandemic Normal, which means the scope of research promised on a $1 million award (pre-COVID-19) will now require more than $1 million to complete. And, the scope of research to be delivered in one year (pre-COVID-19) will now require more than one year. In order to operate effectively and efficiently under the "Pandemic Normal," new measures such as redefining proposal and budgeting guidelines, eliminating overly-burdensome regulations, and related measures are necessary.

The Case Studies from Part IV. show that the projected research output loss due to the COVID-19 pandemic for the twelve months (March 2020 through February 2021) is in the vicinity of 20 percent for each institution—***and in the less optimistic scenario, research output losses could reach 40 percent, and in terms of financial disinvestment, would exceed hundreds of millions of dollars at individual institutions.***

There is little doubt that the Federal Government-Research Institution Partnership is more important than ever. Global competition (especially, with China) is at a critical juncture and our

global leadership status could be at-risk. Until a vaccine is widely available, research universities and other research performers are facing an existential threat. Not only are research finances tenuous, the uncertainty of tuition status, students returning to campus, and safely operating the institution are real threats. Further, immigration issues hover over our research workforce development, which jeopardizes the top minds from the around the world coming to the United States and contributing their diversity and expertise to the United States research enterprise.

Finally, while the research enterprise may appear vulnerable during the COVID-19 pandemic, the same could be said of the United States research enterprise in 1957 after the launch of Sputnik by the Soviet Union. However, we rallied behind the tenacity of university and academic leaders, the foresight of federal policy experts and lawmakers, and the visionary promise of science and discovery to ensure that the United States would be the global leader in research. With that same commitment to and investment in the nation's research enterprise, we can thrive and remain the envy of the world.

CONTRIBUTORS

Dr. Tanju Karanfil, Vice President for Research, Clemson University and **Dr. Melur (Ram) Ramasubramanian,** Vice President for Research, University of Virginia, provided the initial conceptual framework for the Research Impact Metric (RIM) Model and analysis on impact to research output loss and financial disinvestment.

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ADDITIONAL RESOURCES

COGR's FAQs and Resources on COVID-19's Impact to Federal Awards https://www.cogr.edu/cogrs-faqs-and-resources-covid-19s-impact-federal-awards

COGR's Webinar Series on COVID-19 (Available upon request to COGR Members Only) https://www.cogr.edu/cogrs-webinar-series-covid-19

Furlough Programs and Implications for Financial Research Compliance (COGR) *May 2020.* https://www.cogr.edu/sites/default/files/COGR_Furlough_UPDATED_May2020.pdf

Funding Programs and Implications for Financial Research Compliance (Addendum to Finances of Research Universities – June 2014) (COGR) *July, 2020.* https://www.cogr.edu/sites/default/files/COGR_Funding_July1_2020.pdf

Institutional and Agency Responses to COVID-19 and Additional Resources (COGR) https://www.cogr.edu/institutional-and-agency-responses-covid-19-and-additional-resources

Institutional Resources on Ramping Up and Reopening (COGR) https://www.cogr.edu/institutional-resources-ramping-and-reopening

APPENDIX A. HOW RESEARCH OPERATIONS ARE DISRUPTED

During Shut Down

- Idle time caused by shutdown of campus
- Loss of productivity due to remote status
- Loss of productivity for cored facilities and shared resources
- Cancelled travel

Re-Opening

- Restart and Replacement
  - Reestablishing cell lines and animal models
  - Purchasing replacement reagents for those that have expired
  - Inability to work at previous level of efficiency (due to remote status, etc.)
  - Recruiting/training new support staff/students/post-docs if people are no longer available to work in the lab
  - Replacement of donated PPE
  - Loss of labor related to visiting students/staff to labs
  - Loss of productivity for cores and shared resources
- Return to work issues
  - Immuno-compromised people staying at home
  - Slowed return to work due to day-care/school closures
  - Delayed research due to faculty/staff unable to travel and/or stuck in other states/countries
- Other
  - Delayed supply chain
  - Termination of industry and service agreements

Infrastructure

- Lab reconfiguration to operate safely with COVID
- Increased lab costs (or research inefficiencies) related to required density issues
- Lack of PPE to enable research labs to open
- Purchase and implementation of HVAC, air sanitization, increased house-keeping/sanitization requirements
- The "unknowns" related to stalled/stopped research building renovation & construction
- Redirection of entire strategic focus to "operating in a COVID world" and associated opportunity cost
- COVID testing

- Addition of sanitizing stations to building entry/labs, etc. and managing access
- Additional administrative support for management of COVID oversight
- Retesting/calibrating equipment
- Need for increased infrastructure to support remote work access

Pandemic Normal

- Clinical Research:
  - Reduced efficiency for enrolling subjects because people are concerned about coming into clinic for clinical trial
  - Inability to enroll subjects for clinical studies
  - Reenrolling human subjects for trials that were paused
- Return to work issues
  - Immuno-compromised people staying at home
  - Slowed return to work due to day-care/school closures
  - Shift scheduling to accommodate 24 hour shifts
  - Need for ramp-down due to reoccurrence of COVID outbreak

APPENDIX B. RESEARCH UNDER THE PANDEMIC – CHALLENGES AND ADAPTATIONS

Included is a small cross-section of research and activity interrupted by the COVID-19 pandemic. In some cases, the research can be adapted, and the work continues. In other cases, the research completed to-date is at-risk of being lost in its entirety. In all cases, while the challenges to continue the work are significant, passionate and dedicated investigators and research personnel are pursuing new and creative avenues to advance the science and ensure that the hope and promise of life-changing discoveries moves forward and continues to benefit the nation.

Interruptions in Research with At-Risk Teens. A statewide early literacy intervention has operated continuously for a more than decade for at-risk students. In 2019-2020, a group of 750 students completed the intervention and were tested. These students were scheduled to have been tested again at the end of the academic year to determine if gains assessed mid-year held. This assessment could not be completed due to the closing of public schools. A second cohort of 750 students began receiving intervention services mid-year. No initial assessment data were collected from these students due to school closures. These data have been reported annually to school district and state level stakeholders and are used to refine intervention protocols. Researchers have worked through the summer to problem solve virtual data collection. While data collection was interrupted in 2019-2020, procedures will be modified and adjusted depending on the school format used during 2020-2021.

NSF-Advancing Informal STEM Learning (AISL) Program. The pandemic impacted an ongoing NSF-AISL program in three ways: 1) Inability to implement the planned intervention during this time as travel to community sites has been suspended, 2) As a result of the sites closing their doors, the investigators have been unable to maintain consistent contact with community partners; investigators are unclear if employees at these sites are furloughed, no longer employed, or unable to respond for other reasons, and 3) Investigators have had to adjust their timeline for program implementation and data collection, which has led to adjusting the functions of a graduate student who is being funded by this project.

Face-to-face Patient Research and Diabetes Research. Research on the effect of performing exercise on a diabetic patient's blood sugar level after eating is a face-to-face event between patient and researcher. The blood specimen is tested, and observations are made of the exercise performed. Research was halted as the face-to-face research with patients was discontinued as a COVID prevention strategy. This research could not be accomplished as a virtual patient visit because the special machine for the blood sugar testing would need to be brought to the location and one-on-one supervision provided.

Research on End-of-life Conversations with the Elderly. Initially, this research was conceptualized as a face-to-face interaction between the patient, provider, and family members. As the disruption due to COVID-19 approached five months, research re-design came under discussion and the focus for this research has been adapted to emphasize virtual interaction between the patient, provider, and family members. The patient is supported in decisions as the family hears first-hand of their wishes and conceptualizing of novel methods of holding serious conversations about wishes at the end of life take place.

Craniofacial Morphology Research on Children. The purpose of the study is to provide a quantitative assessment of the craniofacial morphology associated with a rare congenital syndrome using 3D images of children's faces that have been diagnosed with the disorder. The primary data collection was to occur at the biannual family conference scheduled for July 2020 in Orlando, FL. The family conference was postponed for at least one year and therefore data collection at the conference could not occur. While some images were able to be collected from clinics and regional conferences, the family conference was an opportunity for hundreds of children with the rare disorder to be in the same place at the same time. Hopefully, the conference will occur next summer, and the data collection will be able to happen then.

Clinical Trial Enrollment (applicable to thousands of projects). Many NIH sponsored clinical trials may take months or years to enroll research subjects due to the nature of the research being conducted. In some cases, these subjects have had routine visits, blood draws, and other in-person interactions for extended periods. COVID has reduced/eliminated the ability to continue these in-person visits, which could mean the loss of these subjects and/or material impact on the quality of the data being collected. Ultimately, this could mean that enrollment would have to start over, setting the project back by months or years, while also jeopardizing the necessary rigor and reproducibility standards.

Graduate Student Research Career and Thesis (affecting thousands and thousands of individuals). Many graduate students receive funding directly from federal sponsors in support of their developing academic and research careers. In many instances, travel to a field site is a critical component of their fellowship. Many of these support awards have limited funding and duration; if a graduate student was planning to travel during this past spring, their entire research thesis could be materially impacted causing them to adjust the thesis objectives materially (or not be able to complete their work). The end result could mean that the student requires an additional full year of financial support to conduct the project.

Support of Undergraduates in Research. Students, both graduate and undergraduate, provide important research support. In one example, undergraduates are critical to interaction with puppies in their early development to better understand their ability to function as service dogs in

various roles such as PTSD support, bomb detection and assistance to disabled persons. This predictive analysis is based on a significant investment of time and personnel and lapses in interaction can have detrimental impact on the research outcomes. Support by undergraduates is critical to the research outcomes but is also an important opportunity for most students in their developing academic and research careers. Further, with the absence of undergraduates, many labs that rely on them as critical resources may have to have more senior staff (graduate students, postdocs, technicians) to take on the undergraduates' roles on projects.

Research on Cognitive Aging, Child Development, Brain Function, and Clinical Psychology (applicable to thousands of projects). Many research projects involving human participants have been delayed significantly as a result of COVID. Laboratories had to pause their research programs at a time that is often when the most significant phase of data collection occurs.

Global Health Research on Pregnancy Outcomes. COVID-19 has impacted health research abroad because travel for the researchers has been significantly impacted, and researchers abroad have been unable to work at their labs or with study subjects. Longitudinal studies of pregnancy outcomes in several studies have been interrupted since March. Researchers have been able to get some information from cell phone interviews of the subjects, but key data such as birth weights have been lost. Some of this longitudinal data, unfortunately, will be unrecoverable.

Study of Earthquakes in Chile. The investigator and a student were scheduled to travel to Argentina and Chile to recover several seismographs, retrieve the data, and pack them to be returned to a collaborating institution in April-May. They were unable to go, so $800K of equipment and project data is unavailable at this time.

Seasonal Travel and Malaria Research. There are various research studies that require the research team to be on site at the early seasonal onset of a disease. One example of this is malaria. If the team cannot be onsite for this critical time period, it could mean that the research is stalled for an entire year.

USDA and Food Research. Finally, investigators funded by the USDA work on a seasonal basis to engage in innovative food and plant research, which benefits the nation and the world by enhancing the world food supply. This research, dependent on the planting and harvest seasons, will continue to be at risk as travel and other disruptions caused by the COVID-19 pandemic persist and affect the normal flow of research and innovation.