Analysis

Analysis of our current standing based on publications and NIH funding. To establish relevant metrics for our current standing using an unbiased approach, we performed an analysis of productivity in terms of publications and grant funding using publicly available databases. For publications we used PubMed and for funding we used NIH RePORTER. For our comparison we chose to look at members of the CIC and also recognized national leaders in our region. These institutes represent both "aspirational peers" and "best in class".

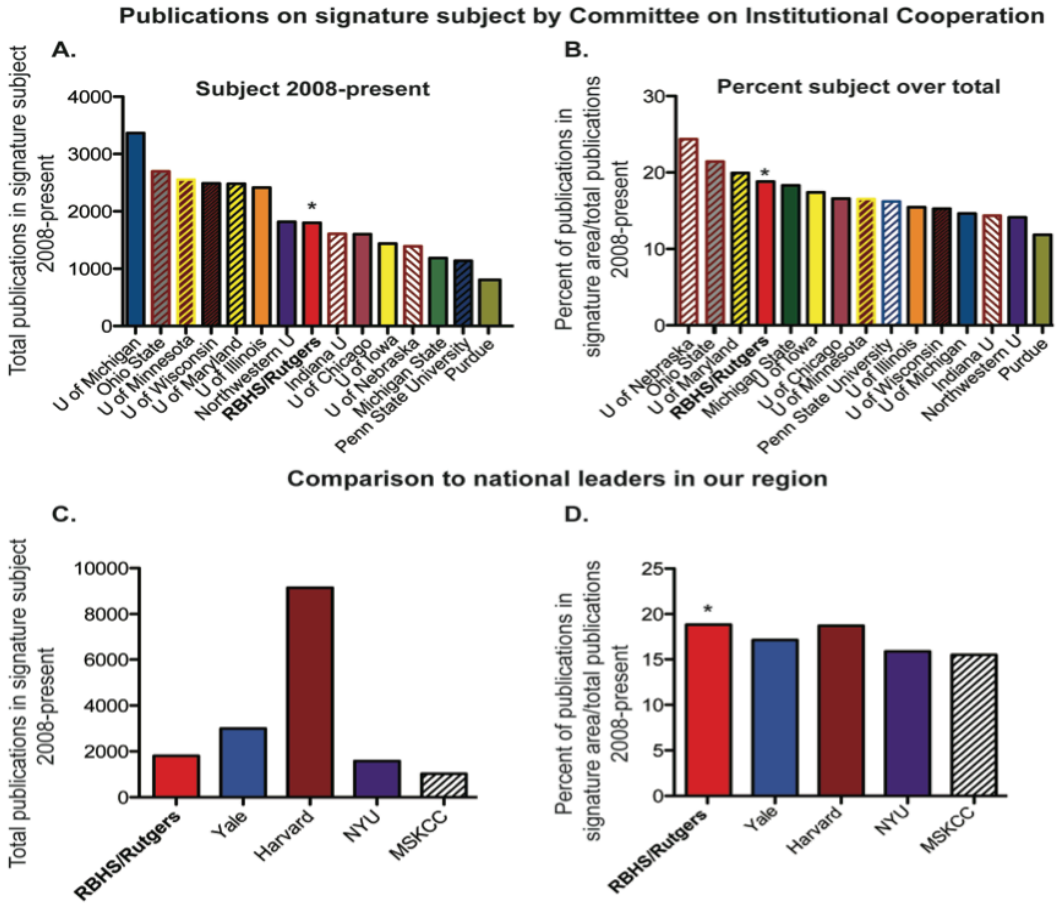

Figure 2: (A) Graph shows total publications in the signature subject for each institution ranked in descending order. (**B**) Graph shows the percentage of publications in signature subject over total publications by each institution. This analysis aims to adjust for institution size. (**C)** Graph shows national leaders in our area in terms of total publications **(D)** and as percentage of total publications.

Publication Analysis: The publication record of CIC members was analyzed in PubMed. A publication period of 2008 to present (4/28/2014) was examined. RBHS/Rutgers was defined as: NJMS, RWJMS, CINJ, CABM and Rutgers University. The keywords used for the search were: immunology or inflammation or infection or vaccine or pathogen or diagnostic and infection or tuberculosis or HIV or drug resistance or parasite. The same key words were used for all institutions shown.

Our analysis shows that the publication record of RBHS/Rutgers in the proposed signature area is very competitive with other members of CIC both in terms of total publications in infectious and inflammatory disease and also when expressed relative to all publications during this period for each institution. As noted by the almost equivalent number of publications of institutions ranked 2-6, the difference between Rutgers/RBHS and the leaders in CIC is not substantial. Thus, with proper investment we are poised to become the top institution in this area amongst all the CIC members. Moreover, after adjusting for total publication output the proposed signature area already constitutes a significant area of productive research at RBHS/Rutgers accounting for almost 1/5 of all published work in this institution. The contribution of RBHS/Rutgers to this subject is competitive not only compared to the public top-tier institutions included in the CIC but also compared to private institutions of national reputation located in our region.

To establish our standing based on funding we examined the NIH RePORTER database. Federal funding from other resources, such as Department of Defense and National Science Foundation are not included in this document due to unavailability of easily accessible database sites for these agencies. Other types of funding, such as state and private foundation funding, were excluded since they are not readily available and are often not comparable indicators of competitive productivity. Also, employing a publicly available database allows us to directly compare Rutgers to other institutions. The total NIH funding over the last five years of our faculty engaged in infectious disease and inflammation was nearly $150 million. We next performed an inter-institutional comparability search using the same keywords and institution names used for obtaining the publications database, during the funding period of 2009-2014. The results of that search across members of CIC are summarized below. In this more limited search our funding totaled nearly $95 million. The reduced amount is due to funded grants not recognized by our search terms. We are clearly highly competitive as compared to CIC member institutes. The top five institutions in funding are also ranked as publishing more articles in this area. Using the higher figure of $150 million in NIH funding for RBHS and comparing that to the top two funded institutions, University of Michigan has 3 times as much funding as RBHS and 1.8 times more papers, University of Wisconsin 2.4 times more funding and 1.3 time more papers. In this type of comparison it could be argued that we have been able to do more with less money.

Institution	NIH funding 2009-2014	Institution	NIH funding 2009-2014
University of Michigan at Ann Arbor	460,243,584	University of Nebraska Medical Center	116,089,156
University of Wisconsin	363,546,475	Pennsylvania State University	112,525,554
University of Minnesota	333,339,503	**RBHS/Rutgers**	**94,603,325**
Northwestern University-Chicago	261,862,708	Michigan State University	65,659,748
University of Illinois-Chicago	245,252,595	Purdue University-West Lafayette	47,755,044
University of Iowa	238,034,159	Indiana University-Bloomington	37,213,257
Ohio State University	205,901,892		

Taken together, these analyses indicate that we are already competitive with many of the institutions in the CIC in this signature area both with regards to publications and competitive NIH funding. We argue that with this significant platform and with appropriate strategic investments, this signature area of research excellence is poised to rapidly emerge as one of the strongest institutions in the CIC and ultimately nationwide.

Strengths

Research themes in Infectious and inflammatory disease

The two research themes of greatest strength in this signature area include:

1. Immunity and inflammation
2. Global pathogen virulence, detection and control

As shown in Fig. 1, an understanding of both these areas is required for research investigating the control of pathogenesis and harmful inflammation. As such these two themes overlap and complement each other providing a strong basis for interdisciplinary collaboration and the development of multi-investigator grants. Current topics of research strength include mucosal immunology, with a particular focus on studies involving infection and inflammation of the lung. We currently have a critical mass of NIH-funded investigators in this specific area of research that includes bacterial (M. tuberculosis), viral (RSV, HIV, Influenza), fungal, and parasitic lung infections. As such we are poised to develop large multi-investigator grant proposals in this specific area. We also have complementary strengths in assessing mucosal responses to diseases including HIV, Treponema pallidum that causes syphilis, and parasitic infections. Our faculty members are also studying the vector-transmitted diseases, including tick-borne diseases that are endemic (Lyme Disease) and emerging (babesiosis and anaplasmosis) in our region and in Europe, sleeping sickness in Africa, and highly prevalent diseases around the world, such as malaria. Another strength includes the diagnosis of early pathogen infection and the development of anti-infective treatments for specific drug-resistant pathogens. Members of this group, including David Perlin (Public Health Research Institute-NJMS) and David Alland (Emerging Pathogens Center-NJMS), have recently obtained a $26M Center of Excellence in Translational Research NIH U19 grant that targets anti-infective drug development for high-threat bacterial agents. Dr. Richard Ebright (Rutgers) also has developed important anti-infective agents and is also a Project PI on the CETR NIH grant mentioned above. Another group led by Sergei Kotenko at NJMS obtained 6M in NIH funding and secured industry partnership to develop novel broad-spectrum antiviral therapeutics. We excel in this area of research excellence as a result of individual faculty with different areas of expertise coming together to build collaborative projects that form the basis for large multi-investigator grants. This funding thus supports high levels of productivity resulting in papers published in high impact journals, which we also have a particular strength in.

Researchers in this signature area of research excellence also have considerable strengths in the commercialization of new licensed technologies. Molecular beacons, developed by Dr. Fred Kramer and others (primarily NJMS-PHRI) have been a source of significant revenue for Rutgers; David Alland (NJMS-EP center) has developed a molecular beacons-based diagnostic assay for drug-resistant MTB and is now extending this technology to detection of other pathogens. Marila Gennaro (NJMS-PHRI) has developed antigens suitable for specific detection of Mtb. Recently, Nikhat Parveen (Microbiology-NJMS) has employed molecular beacons in multiplex assays to detect tick-borne pathogens. Other groups are licensing and patenting new therapeutics, technologies and pathogen compositions to enhance wound healing and to control harmful inflammatory responses, and to prevent and treat viral infections. Arguably, research in infectious and inflammatory diseases has culminated in some of the most effective commercialization of patents and licensing at Rutgers.

The signature area of infectious and inflammatory disease also has strong components in clinical research. The NJMS-Newark-based NIH-funded Clinical Research Site (CRS), led by Dr. Sally Hodder, provides a critical patient sample resource for HIV basic and clinical

research. The retention rate of enrolled subjects is high (97%) and community engagement is an important component of the CRS involving active collaboration with the Newark civic leadership and partnering with the Newark faith community. Therapeutic immunology, involving multiple investigators including Dr. Roger Strair, Dr. Howard Kaufman and Dr. Edmund Lattime (RWJMS, Cancer Institute of New Jersey) utilizes immunology research strengths and core resources at RBHS to develop and test immune-based therapeutics, including monoclonal antibodies, cytokines, vaccines and small molecules that modulate host immune responses. The New Jersey Trauma Center (NJTC), staffed by the faculty of the Division of Trauma and Surgical Critical Care, Department of Surgery at Rutgers-New Jersey Medical School, has been the preeminent academic trauma center not only in New Jersey, but also in the entire tri-state area. In this program, research into sepsis and sterile inflammation includes a number of NIH-funded investigators publishing in high-impact journals. These clinical/translational research programs provide a significant bridge from the bench to bedside for our signature area of research excellence. Taken together, the Infectious and Inflammatory Disease signature area would be a comprehensive institute covering multiple relevant and complementary areas, in some ways comparable to the structure of the Cancer Institute of New Jersey (CINJ).

Core resources:
Core resources enable NIH-funded laboratories to do big science. Successful research programs in infectious and inflammatory disease rely upon cutting-edge technologies that require expensive, specialized equipment and highly trained staff that cannot be typically supported by individual PIs. Rutgers already has considerable strengths in cores that support infectious and inflammatory disease. These include:

1. Flow cytometry: analysis of complex populations of cells, sorting of highly purified cell populations and also single cells for further analyses, e.g. transcriptome studies.
2. Microscopic and whole animal imaging: confocal, deconvolution and multi-photon microscopy; IVIS, MRI, PET for high resolution whole animal imaging including tracking labeled cells and pathogens in vivo
3. Human research: therapeutic and nontherapeutic: includes patient materials and therapeutic immune research programs
4. Proteomics and Genomics: mass spectrometry, next generation sequencing, etc.
5. Clinical research units: Center for clinical and translational science (CCTS; NJMS); Centers for clinical research (CRC:RWJMS); Pediatric CRC-dedicated facility for pediatric clinical research (RWJMS-Dept. of Pediatrics Child Health Institute); these serve as central clearing houses for clinical studies. Provides regulatory support, budgetary analysis and clinical trials support
6. Crystallography core
7. Pharmacokinetics and Pharmacodynamics
8. Biosafety level three laboratory and animal resources, including the National Regional Biocontainment Laboratory
9. Mouse transgenic and knock out core services: two core facilities housed in the Child Health Institute (supported by the CINJ Cancer Center Support grant) and the NJMS provide essential services for small animal modeling of immune system function.

Critical Gaps

Although we have considerable strengths in infectious and inflammatory diseases, there are several areas that, if targeted, would transform our program into one of the top programs in the CIC in this signature research area. These include targeted disbursement of internal funds for: 1) **recruitment of the highest quality faculty** in areas of potential rapid growth; 2)

strengthening our core resources and thereby enhancing our capacity to recruit the highest quality faculty and staff; 3) **promoting increased communication** among faculty and staff with common interests, thereby enhancing the likelihood of increased collaborations and the development of multi-investigator grants.

At both NJMS and RWJMS there is currently a dearth of outstanding junior basic and clinical research faculty. This is partly because budgetary deficits and priorities have limited recruitment of junior faculty over the last five years. The signature area of infectious and inflammatory diseases has a sufficient level of expertise and national recognition to competitively recruit outstanding junior faculty now. Specific targeted areas are described under recommendations.

Although we currently have several outstanding core facilities, these facilities need to be continually updated and strengthened. Internal as well as external funds are needed to maintain these facilities. Philanthropic contributions may also be an important source of funding. Also, new core facilities as well as significant expansion of current core facilities may be required. Specific areas that currently need strengthening include:

1) **Bioinformatics -** support to effectively utilize existing and emerging computational technologies, with a particular emphasis on genomic-scale datasets;
2) **Molecular and Biomathematical modeling**;
3) **Metabolomics -** analysis of cellular metabolites that are either metabolic pathway intermediates or end points;
4) **Clinical microbiology and pathology**;
5) **Flow cytometry -** satellite facilities are required to support investigators in multiple locations; increased capacity for high throughput, single cell acquisition;
6) **Small animal housing** – subpar mouse facilities must be improved to handle, for example, immunocompromised mouse models;
7) **Electron microscopy** – use of state-of-the-art microscopes available in the Physics department at New Brunswick can be effectively expanded for studying infectious diseases by hiring a new faculty member as core operator of Scanning and Transmission Electron Microscopes for biological sciences.
8) **Clinical Research Infrastructure –** further development of a strong clinical component to conduct translational studies from bench to bedside and outreach to the community in order to examine the full impact of the research

Summary of Best in Class

The signature area of infectious and inflammatory disease is one of the top NIH-funded areas of research excellence at Rutgers. As noted in the analysis, it also holds its own within the CIC and institutions of national recognition in our region. We are currently in a position where we can compete with the top schools in the country to recruit outstanding faculty in infectious and inflammatory disease to Rutgers. This capability provides a strong platform to build this signature area of research into the Best in Class. This would include using this potent research program as leverage for development of industry partnerships and for seeing philanthropic contributions. Collaborative partnerships and funding sources are already being developed and identified in this signature area of research. Targeted areas for philanthropic investment include: diabetes, inflammatory skin disease, lung disease, integrative medicine and microbiome studies. As such we already have the springboard needed to build, with targeted investments, one of the top institutions in infectious and inflammatory disease in the country.