Fiscal Year:	FY 2020	**Task Last Updated:**	FY 08/01/2019
PI Name:	Goel, Namni Ph.D.		
Project Title:	Biomarkers as Predictors of Resiliency and Susceptibility to Stress in Space Flight		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Chicago	**State:**	IL
Zip Code:	60612	**Congressional District:**	7
Comments:	NOTE: Formerly at the University of Pennsylvania until July 2019.		
Project Type:	GROUND	**Solicitation / Funding Source:**	2013 HERO NNJ13ZSA002N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	10/01/2014	**End Date:**	06/30/2019
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	1
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	1
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
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Flight Program:			
Flight Assignment:	NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17) NOTE: End date changed to 6/30/2019 per NSSC information, due to PI moving to Rush University and new grant 80NSSC20K0243 issued (Ed., 7/27/2020) NOTE: Extended to 9/30/2020 per NSSC information in September 2019 (Ed., 12/27/19) NOTE: Extended to 9/30/2019 per NSSC information (Ed., 10/16/18) NOTE: End date is 9/30/2018 per NSSC information (Ed., 1/11/17)		

Key Personnel Changes/Previous PI:	August 2019 report: Namni Goel, PhD, Principal Investigator (PI), relocated to Rush University Medical Center (RUMC) officially as of July 1, 2019. This grant is in the process of being transferred to RUMC and NASA grants and HFBP (Human Factors and Behavioral Performance) element management have been informed of the relocation. The grant has not yet been released by the University of Pennsylvania, and therefore all affiliations have been retained in their current state for this report. [Ed. note 12/27/19: due to Task Book system requirements, the PI's affiliation does now show as Rush University, with note about previous affiliation at University of Pennsylvania; a new grant at Rush has been awarded]
COI Name (Institution):	Basner, Mathias M.D., Ph.D. (University of Pennsylvania) Bhatnagar, Seema Ph.D. (Children's Hospital of Philadelphia) Dinges, David Ph.D. (University of Pennsylvania) Kirkpatrick, James M.D. (University of Washington) Weljie, Aalim Ph.D. (University of Pennsylvania)
Grant/Contract No.:	NNX14AN49G
Performance Goal No.:	
Performance Goal Text:	
Task Description:	This proposal is responsive to the NASA Behavioral Health and Performance gap (BMed5) to find individual characteristics that predict successful adaptation and performance in an isolated, confined, and extreme environment, especially for long duration missions. The project also relates to Human Research Program (HRP) Sleep Gap 4 to identify indicators of individual susceptibilities and resiliencies to sleep loss and circadian rhythm disruption, to aid with individualized countermeasure regimens, for autonomous, long duration, and/or distance exploration missions. The proposal is also responsive to BMed 1 and BMed 2, and Sleep Gap 2 and Sleep Gap 9. To address these gaps, this proposal will assess biomarkers as predictors of resiliency and susceptibility (individual differences) to performance stress and sleep loss using the HRP Human Exploration Research Analog (HERA) and the Hawaii Space Exploration Analog and Simulation (HI-SEAS) high fidelity space analog facilities. We will conduct a ground-based experiment—strongly anchored in our previous laboratory-based research—on N=32 healthy men and women (ages 26-55) in the HERA facility (short-duration analog) and on N=6 healthy men and women (ages 21-65) in the HI-SEAS facility (long-duration analog) to determine the predictive validity of a set of relevant, valid, and reliable biomarkers for distinguishing those who are more resilient versus those who are more susceptible to the adverse neurobehavioral effects of the combination of high performance demands and total sleep deprivation (TSD) stressors—two conditions commonly experienced in space flight. These biomarkers include the following: cardiovascular measures (blood pressure, heart rate and heart rate variability, stroke volume, and cardiac output), salivary cortisol, catecholamines (dopamine, noradrenaline, and adrenaline), an inflammatory marker (C-reactive protein; CRP), metabolomic markers (via unbiased metabolomics), and microRNAs (epigenetic markers). The project deliverable will be a countermeasure (set of diverse biomarkers) for distinguishing those who are more resilient versus those who are more susceptible to the adverse neurobehavioral effects of high performance demands and sleep loss stressors. If valid markers of such susceptibility can be found, it will be possible to optimize and individualize crew resources, and mitigate stress and other behavioral health and performance risks autonomously during long-duration space flight.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The project's research will deliver a countermeasure (set of diverse biomarkers) for distinguishing those who are more resilient versus those who are more susceptible to the adverse neurobehavioral effects of high performance demands and sleep loss stressors. If valid markers of such susceptibility can be found, it will be possible to optimize and individualize crew resources, and mitigate stress and other behavioral health and performance risks autonomously during long-duration space flight. This information would also be of use on Earth in applied occupations that demand similar risks and stressors.
Task Progress:	We integrated the complex, multifaceted five-day stress and sleep loss experiment into HERA and successfully collected data in all four 14-day 2015 and all four 30-day 2016 missions (N=32 crewmembers). These data include the following biomarkers: blood markers from 6 time points in 32 crewmembers (190 blood markers; n=2 crewmembers did not participate in one biomarker assessment); 2 saliva markers each from 6 time points in 32 crewmembers (382 saliva markers; n=1 crewmember did not participate in one biomarker assessment); blood pressure markers from 6 time points in 32 crewmembers (191 blood pressure markers; n=1 crewmember did not participate in one biomarker assessment); stroke volume and cardiac output from 6 time points in 32 crewmembers (191 stroke volume and cardiac output markers; n=1 crewmember did not participate in one biomarker assessment); and heart rate from 6 time points in 32 crewmembers (189 heart rate markers: 3 heart rate monitor data points were not collected due to n=2 crewmembers mistakenly not turning on the heart rate device and n=1 crewmember not participating in one biomarker assessment; however, heart rate data collected from the echocardiography and/or blood pressure devices can be used as needed). We also have data from 11 neurobehavioral tests for 32 crewmembers (348 neurobehavioral tests; one crewmember did not participate in 4 neurobehavioral assessments). Almost all the missing data can be attributed to one crewmember who experienced a medical emergency. Finally, we have continuous actigraphy data on n=16 crewmembers for 14-days each (a total of 224 days of actigraphy) and on n=16 crewmembers for 30-days each (a total of 480 days of actigraphy). Analyses of the wrist actigraphy data from the four 14-day HERA missions of 2015 (n=16) and the four 30-day HERA missions of 2016 (n=16) indicate crew members were compliant with the dictated sleep-wake times at baseline and recovery, and were not sleeping during the total sleep deprivation (TSD) night. As expected for these 32 crewmembers, on average, the performance variables show significant impairment with TSD (with individual differences in neurobehavioral responses). Thus, the sleep loss manipulation in HERA was highly effective. We successfully completed a 17-day initial “shakedown” mission in November 2017 on N=6 subjects. Two miRNA samples were not collected due to blood flow issues with the blood draws, and one NTB (Neurobehavioral Test Battery) test bout was not collected; all other pilot data were successfully collected. We recently successfully completed a 4-month, long duration mission in NEK (Nezemnyy Eksperimental’nyy Kompleks, the new long-duration analog, IMBP--Russian Institute for Biomedical Problems facility) in July 2019 on N=6 subjects. [Ed. note 7/27/2020: Project continues with same Principal Investigator Dr. Namni Goel at Rush University; see project with same title and grant # 80NSSC20K0243 for subsequent reporting]
Bibliography Type:	Description: (Last Updated: 09/28/2023)

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