Fiscal Year:	FY 2017	**Task Last Updated:**	FY 01/24/2018
PI Name:	Ebert, Douglas Ph.D.		
Project Title:	Clinical Outcome Metrics for Optimization of Robust Training		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Smart Medical Systems and Technology Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **ExMC**:Exploration Medical Capabilities		
Human Research Program Risks:	(1) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	douglas.j.ebert@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	281.667.1335
Organization Name:	KBR/NASA Johnson Space Center		
PI Address 1:	KBR Space and Mission Solutions 2400 NASA Pkwy		
PI Address 2:	311		
PI Web Page:			
City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	36
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2013 HERO NNJ13ZSA002N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	06/01/2014	**End Date:**	05/31/2017
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Young, Millennia Ph.D. (Wyle Laboratories) Cole, Richard M.D. (The University of Texas Medical Branch) Kerstman, Eric M.D. (The University of Texas Medical Branch) Byrne, Vicky M.S. (Lockheed Martin Astronautics) Garcia, Kathleen B.S. (Wyle Integrated Sciences and Engineering Group) Sargsyan, Ashot M.D. (Wyle Laboratories) McGuire, Kerry Ph.D. (NASA Johnson Space Center) Gibson, Charles (Wyle Integrated Sciences and Engineering Group)		
Grant/Contract No.:	NCC 9-58-SMST03801		
Performance Goal No.:			
Performance Goal Text:			

Task Description:

The substantially different profiles of human exploration missions beyond Low Earth Orbit pose many challenges for the design of their medical support systems. The success of inflight medical care (from diagnosis to emergency and non-emergency treatment) will depend on proper execution of respective medical procedures, which may be hindered by insufficient onboard expertise, asynchronous communications (time delays), and longer time lags between crew medical officer (CMO) training and actual mission medical operations. Thus, exploration missions would ideally be equipped for autonomous medical care. For extreme operational settings with limited resources such as a deep space-faring vehicle, it is critical to consider not only the immediate outcomes of procedures, but also the consequences of missed diagnoses or unsuccessful procedures that may affect the entire mission. This experiment was designed to address the above concerns by examining the clinical outcome differences between physicians and non-physicians through standardized simulation testing, in both near-term clinical metrics and long-term mission outcomes. In addition, the project sought to improve on CMO training.
The ultimate goal of the work was to address the Human Research Program's Exploration Medical Capability (ExMC) Risk of Adverse Health Outcomes & Decrements in Performance due to Inflight Medical Conditions. This project moves NASA closer to resolving the ExMC knowledge gap Med08: We do not have quantified knowledge bases and modeling to estimate medical risk incurred on exploration missions. The project also addresses two additional ExMC gaps and three gaps under the Human Factors and Behavioral Performance Element's Risk of Performance Errors Due to Training Deficiencies.

The experiment used a two-tier approach. The first tier examined raw clinical outcome metrics by evaluating the performance of both physicians and non-physicians in a medical simulation laboratory using specific medical procedures and conditions. The second tier examined the mission-long impacts of the procedural outcomes obtained in Tier 1. For tier one, the COMfORT team designed training protocols and a training and testing software tool in collaboration with Butler Graphics (Detroit, MI). In addition to four hands on medical procedure modules, the software includes a differential diagnosis exercise to evaluate the ability of participants to correctly diagnose and manage simulated medical conditions. Using clearly defined outcome metrics, these carefully crafted medical simulations were used to compare the success of procedure performance and diagnostic decision-making by physicians versus non-physicians. The simulated procedures were: fundoscopic examination, kidney/urinary ultrasound, endotracheal intubation with a laryngeal mask airway device, ultrasound-guided intravenous catheter insertion, and a differential diagnosis exercise. Test subjects were evaluated either at three, six, or nine months after their initial training to assess trends in their performance over time. Overall, success rates were higher and time to completion shorter for physicians than for non-physicians, but the differences were not as great as expected. Furthermore, we could not demonstrate a clear decline in their procedural success rates due to a detraining effect over the course of nine months, as we had originally hypothesized. This was likely due to the high effectiveness of the just-in-time (JIT) training tool that was available to all participants at all time points. This interpretation is supported by consistently high software usability ratings collected during each session. Despite extensive training and JIT guidance, physicians still did not perform flawlessly, revealing the danger of medical risk underestimation due to over-reliance on a physician that will not be always successful if not current and active in the given subspecialty or procedure.

In the second tier of the project, we used the outcomes of the four simulated procedures and the diagnostic exercise as input for a modified version of the NASA Integrated Medical Model (IMM) to analyze the effect of imperfectly performed individual procedures on overall clinical outcomes and the consequent mission impacts. A modified version of the IMM was created, which accommodated failed diagnoses and procedures. Laboratory simulation output became IMM input, with model results informing a novel set of outcome metrics to more accurately estimate the mission impact of medical procedure outcomes. IMM runs similarly demonstrated that physicians performing medical procedures resulted in lower risks of evacuation and loss of crew life (LOCL) over the course of several mission profiles, although the differences between physicians and non-physicians were not as great as expected. Both physicians and non-physicians resulted in higher risk than IMM currently estimates, due to the current IMM default of 100% successful diagnosis and treatment of infight medical conditions. The crew health index (CHI) varied with medical provider, but not substantially. Short- and long-term outcomes were used to 1) define differences between physician and non-physician CMOs, 2) refine the outcome metrics themselves, and 3) refine and validate our novel medical training products.

Comparison of physician and non-physician outcomes in both tiers directly addresses the value of including physician CMOs on Exploration missions. Novel training products were developed, refined, and validated to improve future medical outcomes and provide a practical training framework for multiple disciplines. In addition to these benefits, the IMM enhancements allow for the variable success of diagnostic and interventional procedures that will strengthen crew health predictions and may expose unidentified medical resource gaps.

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

Through the analysis of performance (raw metrics) and modeling (long-term outcome metrics), this team has outlined the clinical outcomes when physician versus non-physician CMOs perform medical procedures. Training methods and materials have been validated and the staggered testing paradigm has informed questions about the rate of skills/knowledge decay when high quality just-in-time training materials are provided. Training materials for specific medical conditions and their associated treatment protocols have been updated based on the types of errors and usability issues that were discovered. Training products developed through this work are expected to serve as an advanced template for other training programs. A module providing expanded functionality has been added to the NASA Integrated Medical Model which will strengthen predictions for spaceflight mission impacts.
While NASA missions (particularly exploration class missions) have special requirements for medical training and knowledge retention, this is not a problem specific to spaceflight. The problem of maintaining the proficiency of minimally trained medical caregivers and the changing recommendations associated with this training (e.g., CPR training) are evidence of the need for more information in this area. Additionally, the rapidly expanding field of telemedicine is increasing the demand for effective means of teaching non-medically trained personal to assist with or perform medical tasks. This research has provided a set of refined metrics linking both short- and long-term clinical outcomes to training deficiencies. These metrics can easily transfer to the medical teaching arena and be applied to levels from medical schools to basic CPR classes and telemedicine. Further, this research has yielded refined procedural training products which can also be transferred to educational settings. These tools are expected to become a template for expanded use in medical as well as other types of technical training (terrestrial and space applications) and because of their intuitive nature are expected to become excellent outreach tools as well.

Task Progress:	In the past year, the team has completed recruitment of all test subjects and completed all training and evaluation sessions (over 200 total sessions). From a total of 151 interest survey responses (65 physician and 86 non-physician), 67 operator subjects were recruited and completed their training, baseline, and retest sessions. The 3 month group included 10 physicians and 10 non-physicians, 6 month group included 12 physicians and 12 non-physicians, and the 9 month group included 12 physicians and 11 non-physicians. Only 3 subjects dropped from the study prior to completing the retest session (two physicians and one non-physician). The study also relied on a pool of 23 NASA Test Subject Screening (TSS) volunteers for the live patient portions of the evaluation sessions (fundoscopy and kidney/bladder ultrasound modules). Image quality analysis was completed for fundoscopy and ultrasound imagery, and all success metric and software use data has been compiled. Software acceptability and usability ratings have also been tabulated for presentation. Our medical simulations were linked to Integrated Medical Model (IMM) conditions to provide a resource map for integration of our success metrics into IMM as input data. IMM code modifications were completed and tested. IMM runs were completed for lunar 21 day, International Space Station (ISS) 6 month, ISS 1 year, and 2.5 year Mars missions using current assumptions of 100% medical task performance, and both baseline and detrained performance data from our evaluations. Software user comments were compiled and potential software improvements were identified based on a balance of criticality and ease of implementation in the current software structure. An updated version of the software was produced and is available online for demonstrations. A software User's Guide was also generated. Baseline session data was compiled and presented at Human Research Program Investigators Workshop (HRP IWS) 2017, and the team has provided project summary and software demonstration presentations at NSBRI (National Space Biomedical Research Institute) Headquarters (ATD), at the Exploration Medical Capability Forum, and also for the Human Factors and Behavioral Performance group at Johnson Space Center. Multiple future collaborative options are being pursued.
Bibliography Type:	Description: (Last Updated: 03/03/2016)