Cancer Risk Assessment And Mitigation for Exploration Missions

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Abstract:

Estimates of the risk of radiation carcinogenesis from galactic cosmic rays (GCR) and solar particle events (SPE) is reviewed. The NASA Space Cancer Risk (NSCR) model (2010) [1-3] was developed as a revision to the model from the NCRP Report 132 (2000) based on more recent epidemiology data and the formulation of track structure based radiation quality factors for solid cancer and leukemia risk estimates. NSCR-2010 was reviewed by the National Research Council (2012) [4], and a revision to the NASA model, NSCR-2012 (Cucinotta *et al*., in preparation), addresses the recommendations from the NRC report. Age and gender specific models with uncertainty assessments based on human epidemiology data for low LET radiation combined with relative biological effectiveness factors (RBEs) and dose- and dose-rate reduction effectiveness factors (DDREF) to extrapolate these results to space radiation exposures are considered the current "state-of-the-art" [4]. The NSCR model considers tobacco usage in the classification of radiation workers and their risk estimates. Most astronauts are classified as life-time never-smokers, which is estimated to significantly reduce cancer risks due to radiation exposure. A major challenge to the current approach to cancer risk estimates are Non-Targeted Effects (NTE), which include bystander effects and genomic instability, which has been observed in cell and animal models of cancer risks. NTE's could lead to significant changes in RBE and DDREF estimates for GCR particles, and distinct risk factors related to individual sensitivity and countermeasure effectiveness. We discuss methods to include NTE's in uncertainty analysis and to design experiments to provide quantitative data for cancer risk assessment models.

A longer-range challenge for space radiation research is the design and validation of effective mitigator's to cancer risk. Biological countermeasure approaches for GCR cancer risks are challenged by the chronic exposures of long missions (up to 3 years), the high LET components of the GCR, healthy worker effects, and competing risks for non-cancer diseases to be faced by astronauts. We discuss emerging shielding approaches [5], and biomarkers and biological countermeasures approaches to reduce space radiation cancer risks, that can be used as a starting point for a long-range research strategy. The large number of studies that will be needed for developing effective mitigator's of GCR risks, suggest a new cost effective strategy for mitigation research at the NASA Space Radiation Laboratory (NSRL) is needed, and will be discussed in our report.

[1]. Cucinotta, F.A., Chappell, L., and Kim, M.Y.: Space Radiation Cancer Risk Projections and Uncertainties-2010. NASA TP 2011-216155.

[2]. Cucinotta, F.A. and Chappell, L.J.: Updates to Radiation Risks Limits for Astronauts: Risks for Never-smokers. *Radiation Research* **176,** 102-114, 2011.

[3]. Cucinotta, F.A., Chappell, L.J., Kim, M.Y., and Wang, M.: Radiation Carcinogenesis Risk Assessments for Never-Smokers. *Health Physics* (in press), 2012.

[4]. National Research Council: Technical Evaluation of the NASA Model of Cancer Risk to Astronauts Due to Space Radiation. The National Academy Press, Washington D.C., 2012.

[5]. Durante, M., and Cucinotta, F.A.: The Physical Basis for Radiation Protection in Space. *Reviews of Modern Physics* **83**, 1245-1281, 2011.