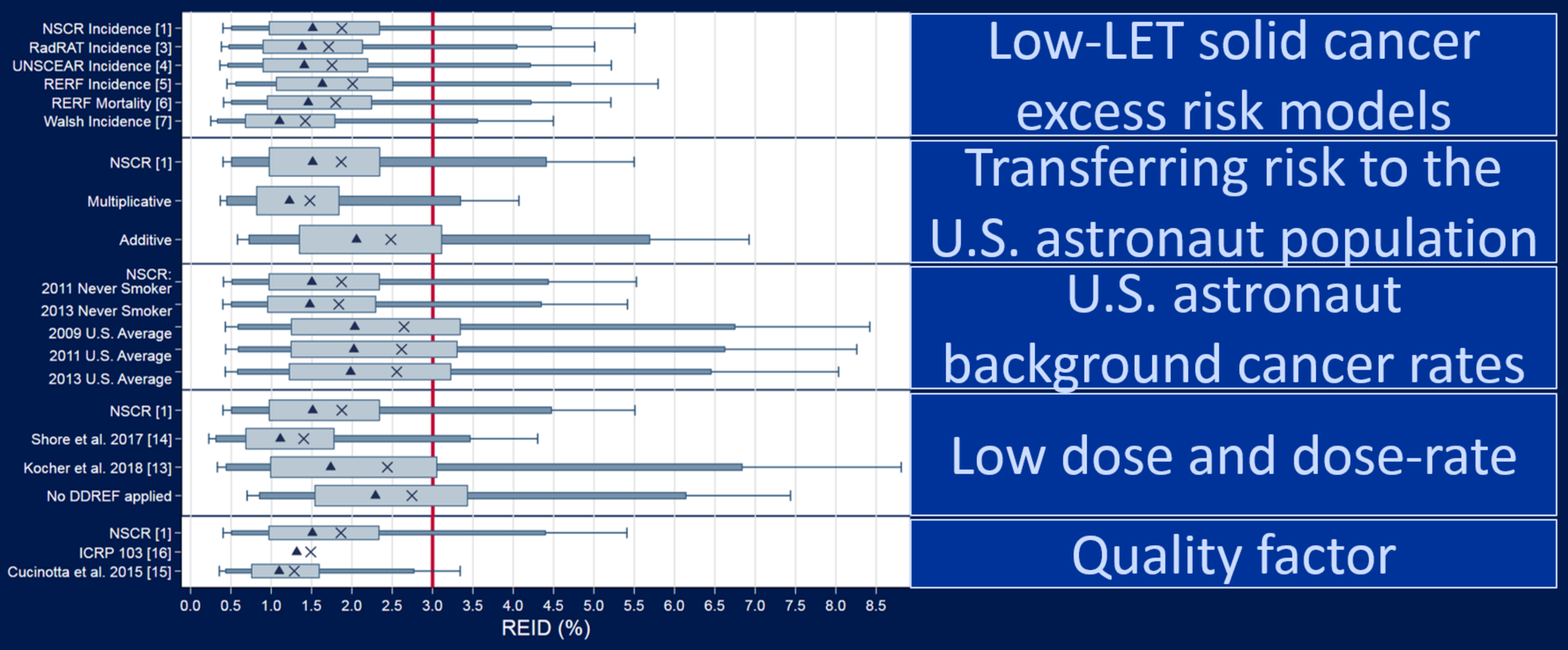

Sensitivity analysis of the NASA Space Cancer Risk Model

Lori J. Chappell[1], S. Robin Elgart[2], Mark R. Shavers[1]
[1]KBR and [2]University of Houston

Overview

NASA currently limits astronaut exposures to an excess 3% risk of exposure-induced death (REID) from cancer at a 95% confidence level. There are several uncertainties involved when estimating REID for the space radiation environment that are incorporated into the NASA Space Cancer Risk (NSCR) model. These uncertainties are characterized by probability distribution functions, and the combined uncertainty is propagated through the calculation of REID using Monte Carlo simulations. The following uncertainties are explored in this poster: uncertainty associated with the atomic bomb survivor Life Span Study (LSS) from which the excess risk is estimated; transfer of the LSS model to a US astronaut population; extrapolation of the high doses and high dose-rates of the LSS model to a low dose and low dose-rate exposure; and extrapolation of the low linear energy transfer (LET) exposures of the LSS model to higher-LET exposures using risk cross sections or quality factors. Below are the mission and astronaut parameters used for the calculations displayed in this poster:

Mission

- 1-year lunar planetary
- Mid solar cycle

Astronaut

- Female
- 40 years old

Methods

The current version of NSCR [1] is used as a baseline for all comparisons. To limit the number of possible variations, only a single uncertainty in the model was changed at a time. Analytica [2] was used to run 50,000 Monte Carlo samples for each variation. Resulting total REID percentage distributions were visualized using modified box and whiskers plots (Figure).

** Whiskers represent a 95% uncertainty interval. Thin boxes represent a 90% uncertainty interval. Thick boxes represent the interquartile range. Triangles represent the median, and X symbols represent the mean. The vertical red line at 3% represents the current NASA REID limit.*

Results

The colon absorbed dose for this mission is 15 cGy. The Figure visualizes changes in REID (%) summary statistics after adjustments to different uncertainties in the NSCR model. The median and mean provide best estimates for the REID after this 1 year lunar mission; the mean is slightly more conservative due to the skewed distribution. The best estimates are all less than the current 3% NASA limit. However, in each case the upper limit of the 95% uncertainty interval for this scenario exceeds the NASA career limit of 3% REID.

Conclusion

This analysis highlights some of the complexity of risk estimation for NASA astronauts. Risk estimation for an international community is further complicated by multiple factors, including differing background cancer rates that have not been captured here. Guidance from local, national, and international independent advisory bodies is valuable to space agencies to ensure the safety of all who travel in space.

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