



Dose-Effects Models for Space Radiobiology: An Overview on Dose-Effect Relationships

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Space radiobiology is an interdisciplinary science that examines the biological effects of ionizing radiation on humans involved in aerospace missions. The dose-effect models are one of the relevant topics of space radiobiology. Their knowledge is crucial for optimizing radioprotection strategies, the risk assessment of the health hazard related to human space exploration, and reducing damages induced to astronauts from galactic cosmic radiation. Dose-effect relationships describe the observed damages to normal tissues or cancer induction during and after space flights. They are developed for the various dose ranges and radiation qualities characterizing the actual and the forecast space missions.

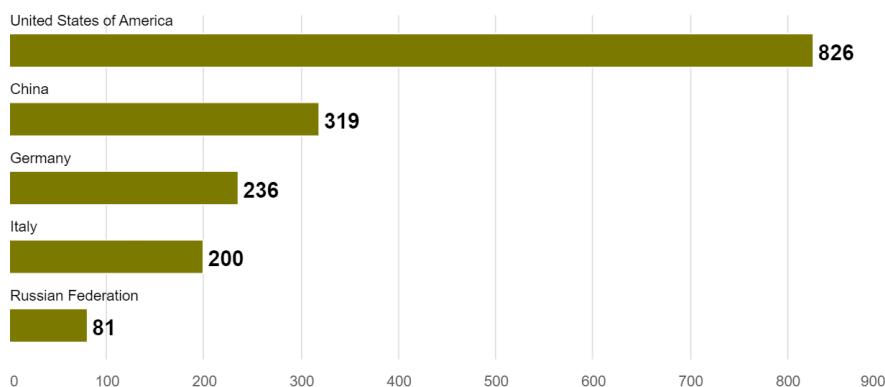
Based on a *PubMed* search including 53 papers reporting the collected **dose-effect relationships after space missions or in ground simulations**, 7 significant dose-effect relationships (e.g., eye flashes, cataract, central nervous systems, cardiovascular disease, cancer, chromosomal aberrations, and biomarkers) have been identified.

For each considered effect, the absorbed dose thresholds and the uncertainties/limitations of the developed relationships are summarized and discussed. The current knowledge on this topic can benefit from further *in vitro* and *in vivo* radiobiological studies, an accurate characterization of the quality of space radiation, and the numerous experimental dose-effects data derived from the experience in the clinical use of ionizing radiation for diagnostic or treatments with doses like those foreseen for the future space missions.

The growing number of pooled studies could improve the prediction ability of dose-effect relationships for space exposure and reduce their uncertainty level. Novel research in the field is of paramount importance to reduce damages to astronauts from cosmic radiation before Beyond Low Earth Orbit exploration in the next future. The study aims at providing an overview of the published dose-effect relationships and illustrates novel perspectives to inspire future research.

Model	Study Type	Dose Range/Threshold or LET	#Papers	Reliability	Priority
Eye Flashes	Spaceflight	LET>5-10 KeV/μm	4	****	*
Cataract	Spaceflight	8 mSv	5	***	***
CNS	Ground/Simulations	100-200 mGy	11	**	*****
CVD	Spaceflight	1000 mGy	4	*	***
	Ground/Simulations	0.1-4,500 mSv	8		
Cancer	Spaceflight	< 100 mGy	2	***	*****
	Ground/Simulations	< 100 mGy	9		
Biomarkers or Chromosomal Aberrations	Spaceflight	<5-150 mGy	11	***	*****
	Ground /Simulations	< 10,000 mGy	4		
Other Risks	Ground/Simulations	2,000 mGy	2	*	***

*= Very Low, **=Low, ***=Medium, **** = High, ***** = Very High.



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