

Human Research Program



Characterization Of Evidence For Human System Risk Assessment

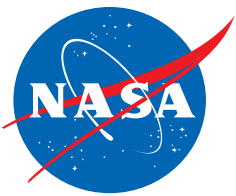
Human Research Program: Susan Steinberg

Lifetime Surveillance of Astronaut Health: Mary Van Baalen & Meredith Rossi

Human Health & Performance: Gary Riccio

Human System Risk Board: Elkin Romero & Dave Francisco

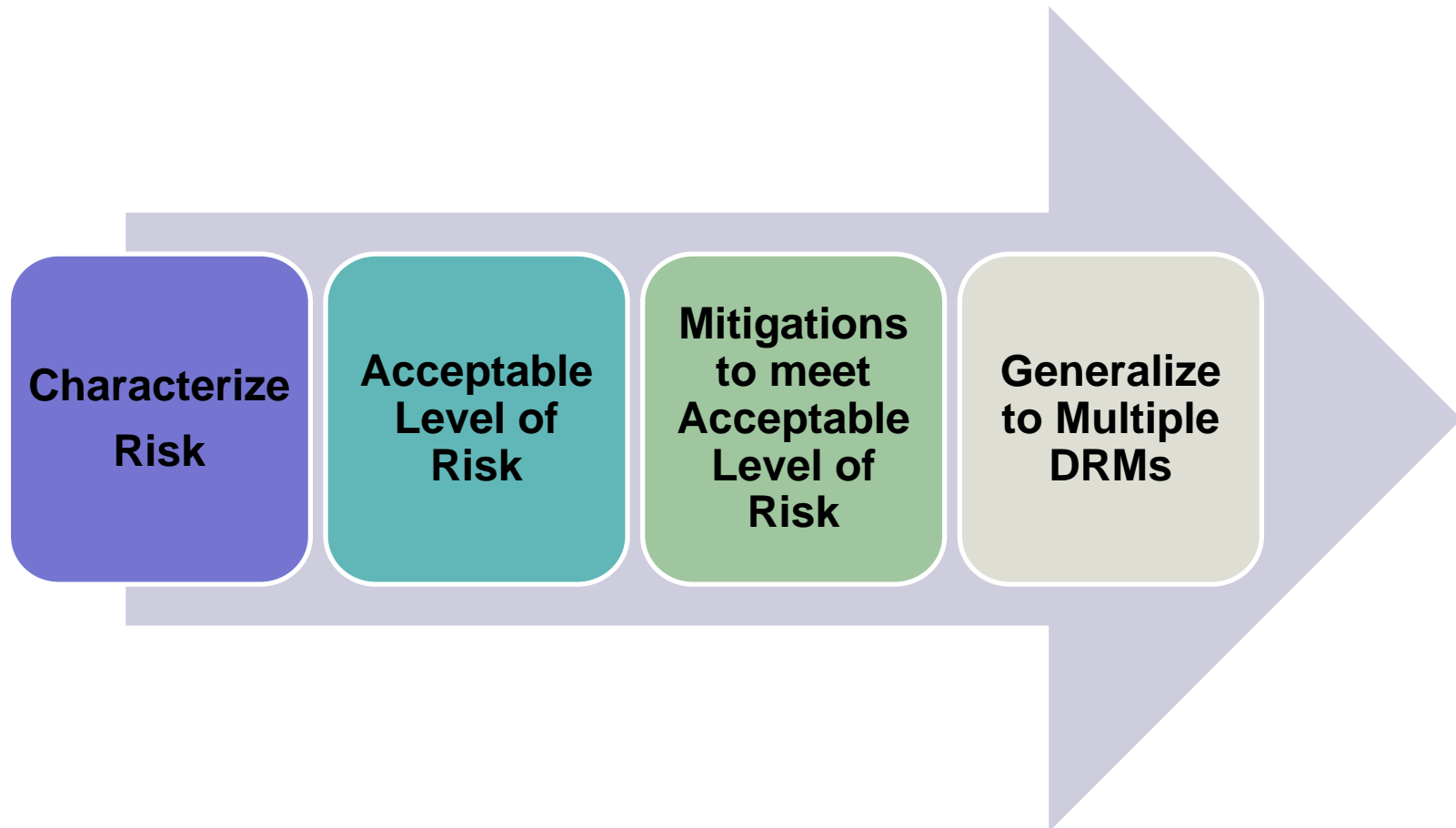
2016 HRP Investigators Workshop



Evidence-Based Human System Risk Management

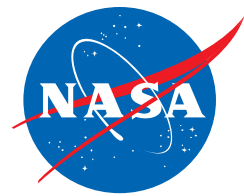
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- Integration and interpretation of all available evidence informs the risk statement that describes the relationship between spaceflight hazards and an outcome of interest.





Evidence Integration for Human System Risk Management



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Spaceflight research (LSDA)

Environmental/
Operational

Medical
Data

Lifetime Surveillance of
Astronaut Health (LSAH)

HRP
Research

Non-NASA
S&T
Ecosystem

Evidence

GER mods

PRR

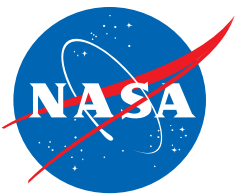
Metrics

Risk
Assessment &
Disposition

Human System Risk Board

Office of Chief Health and
Medical Officer

Human Exploration
and Operations
Mission Directorate



Challenges of Characterizing Evidence

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Independent Variable

- Hazards of spaceflight, such as space radiation or low gravity, cannot be entirely duplicated in a single terrestrial (Earth-based) analog.

Risk Metric

- Derived from available prevalence or incidence data, which limits rigorous interpretation.

Small 'n'

- Long timeframe for obtaining adequate spaceflight 'n'.

Levels of Evidence

- Randomized control trials are unattainable in spaceflight; theory and data vary with respect to causal specificity and power.

Advanced Analytics

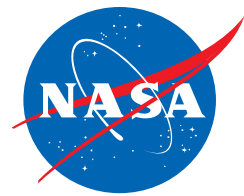
- Astronaut private data use for secondary analysis, aggregation, and modeling beyond that achieved in isolated experimental designs.

Transition to Operations

- Transdisciplinary enterprise across the physical, biological, behavioral, and social sciences with clear outcomes.

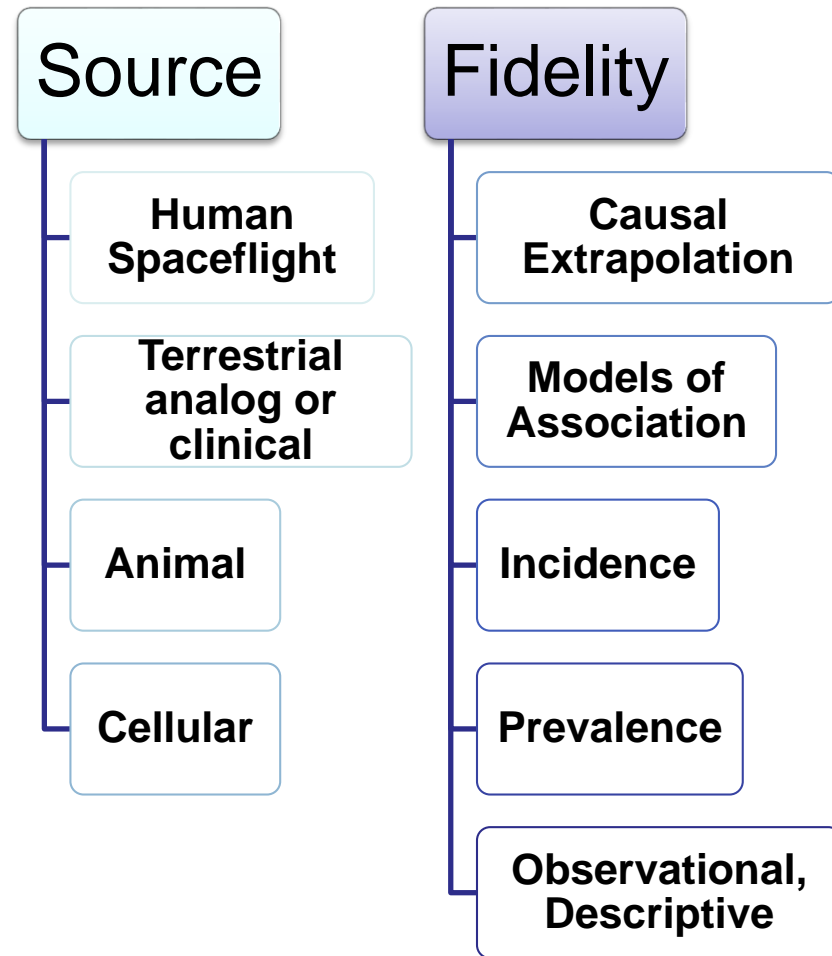


Synthesis of Data Source X Fidelity



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- ✓ Human space flight data - definitive data source for establishing a relationship between spaceflight hazard and outcome for most issues, even though low 'n' and attributability will place limitations on statistical analysis.
- ✓ Fidelity of theory or models- strength of the relationship between spaceflight hazard and the outcome of interest .
- ✓ Different types of data (evidence) are relevant to different questions (claims) and not all risks will require spaceflight data to make an adequate assessment.
- ✓ “Best evidence” is understood in terms of risk specificity and generalizability.



❖ “Best” level of evidence may be spaceflight data interpreted in the broader context of theory and data from terrestrial randomized controlled clinical trials.

Human System Risks – Working Construct for Levels of Evidence

Risk of Spaceflight-Induced Intracranial Hypertension/Vision Alterations

		> 10 IIH Neutral	
1-Carbon 2			LSAH
	2 Mice SSP		1
		IIH – Idiopathic Intracranial Hypertension	2

Evidence Source

Cellular
Flt, terrestrial, omics

Animal
Flight, terrestrial

Terrestrial
Clinical, Analog

Spaceflight
Human physiology, environment

Evidence Description

Direct linkage between hazard, effect on humans & potentially countermeasures

Related linkage between hazard, effect on humans & potentially countermeasures.

Probability of occurrence of a condition in a population within a specified period of time

Proportion of cases of a condition in a population at a given time

Case study with multiple subjects

Detailed examination of an individual, descriptive study design that does not look for cause & effect.

Causation
Evidence Synthesis

Association
Risk Understanding

Incidence
Risk Quantification

Prevalence
Risk Assessment

**Case Series/
Descriptive Study**

Case Study
Descriptive

Impact on Risk Assessment

Ultimate impact - defines the ability to understand, mitigate risk & extrapolate to DRMs

Significant impact - defines the ability to understand and mitigate

Further quantifies risk understanding & may impact mission design

Ability to start to quantify risk assessment

Moderate impact may trigger risk or enhance metric

Limited impact may trigger concern

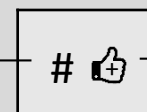
Note: The "State of Knowledge" field within the Risk Summary should contain a comprehensive account and overall assessment of the evidence indicated.

Legend

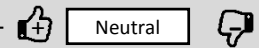
Risk Metric
New Evidence



of Publications or LSAH data



Evidence Assessment vs. Risk Statement



Human System Risks – Working Construct for Levels of Evidence

Risk of Renal Stone Formation

	> 100 👍	> 100 👍	
	> 100 👍	> 100 👍	
		> 100 👍	LSAH 👍
		> 100 👍	
		> 100 👍	
		> 100 👍	
		> 10 👍	

Cellular
Flt, terrestrial, omics

Animal
Flight, terrestrial

Terrestrial
Clinical, Analog

Spaceflight
Human physiology, environment

Data Source

Fidelity of Evidence (LOEs)

Causation

Drawing conclusion(s) about a connection based on the conditions of the occurrence of an effect, by analyzing the response of the effect/dependent variable when the cause/independent variable is changed.

Association

Any relationship between two qualities that makes them dependent (related to one another); when two or more variables vary according to a pattern.

Incidence

the measure of the probability of occurrence of a condition in a population within a specified period of time; rate of occurrence of new cases.

Prevalence

proportion of cases of a condition in a population at a given time.

Case Series

often a case study with multiple subjects; descriptive study design.

Case Study

in-depth and detailed examination of a subject of study, i.e., the case; descriptive study design that does not look for cause and effect.

Exposure

measurement of spaceflight environment - no correlation to outcomes

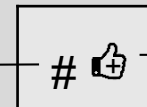
Note: The "State of Knowledge" field within the Risk Summary should contain a comprehensive account and overall assessment of the evidence indicated.

LEGEND:

Risk Metric
New Evidence



of Publications
or LSAH data

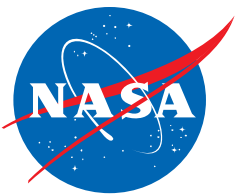


Evidence Supports



Risk Statement

Level of Evidence	Evidence Details	Evidence Impact on Risk Assessment	Evidence Sources	
<p><u>Causation</u></p> <p>Connection based on the conditions of the occurrence of an effect, by analyzing the response of the effect/dependent variable when the cause/independent variable is changed.</p>	<p><u>Direct</u> linkage between hazard, effect on humans & potentially countermeasures</p>	<p>Ultimate impact - defines the ability to understand, mitigate risk and extrapolate to DRMs</p>	<p>Integration of Spaceflight Medical. Occupational Surveillance, descriptive and mechanistic research studies and terrestrial data</p>	Risk Metrics, Understanding & Mitigation
<p><u>Association</u></p> <p>Relationship between 2 qualities that makes them dependent; variables vary according to a pattern.</p>	<p><u>Related</u> linkage between hazard, effect on humans & potentially countermeasures.</p>	<p>Significant impact - defines the ability to mitigate risk, countermeasure assessment</p>	<p>Integration of Spaceflight Medical. Occupational Surveillance, descriptive and mechanistic research studies and terrestrial data</p>	
<p><u>Incidence</u></p> <p>the measure of the <u>probability/rate</u> of occurrence of a condition in a population within a specified period of time</p>	<p>Modeling may be utilized to enhance probability calculations</p>	<p>Further quantifies risk - may impact mission design</p>	<p>Integration of Spaceflight Medical. Occupational Surveillance, descriptive research studies and terrestrial data</p>	
<p><u>Prevalence</u></p> <p><u>Proportion</u> of cases of a condition in a population at a given time.</p>	<p>Extended occupational surveillance and/or combined with research descriptive studies</p>	<p>Ability to start to quantify risk assessment</p>	<p>Combination of data from medical, occupational surveillance and descriptive research studies</p>	
<p><u>Case Series/Descriptive Study</u></p> <p>often a case study with multiple subjects; descriptive study design.</p>	<p>Preliminary occupational surveillance and/or research descriptive studies</p>	<p>Moderate impact may trigger risk or enhance metric</p>	<p>Usually data from medical, occupational surveillance and/or descriptive research studies</p>	Descriptive
<p><u>Case Study</u></p> <p>in-depth and detailed examination of an individual, descriptive study design that does not look for cause and effect.</p>	<p>Usually an observation on an individual - review of medical data</p>	<p>Limited impact - descriptive on very limited n May trigger concern</p>	<p>Data from medical and/or occupational surveillance activities</p>	



Framework for Evidence Synthesis

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A unified framework for aggregating and assessing different kinds of evidence provides a “common language” for evidence-based decision making process:

- Consistent
- Traceable
- Transparent

Provides the foundation for science-based decisions

- Principled (theory)
- Outcomes-driven (models)
- Replicable, Generalizable



Scientific theory and models support translation of research to operations in an environment where engineers, scientists, physicians, and managers all engage in analyzing the trade space of vehicle design, standards, requirements and solutions for spaceflight.