

This Directed Acyclic Graph and write-up is an excerpt from a larger NASA document.

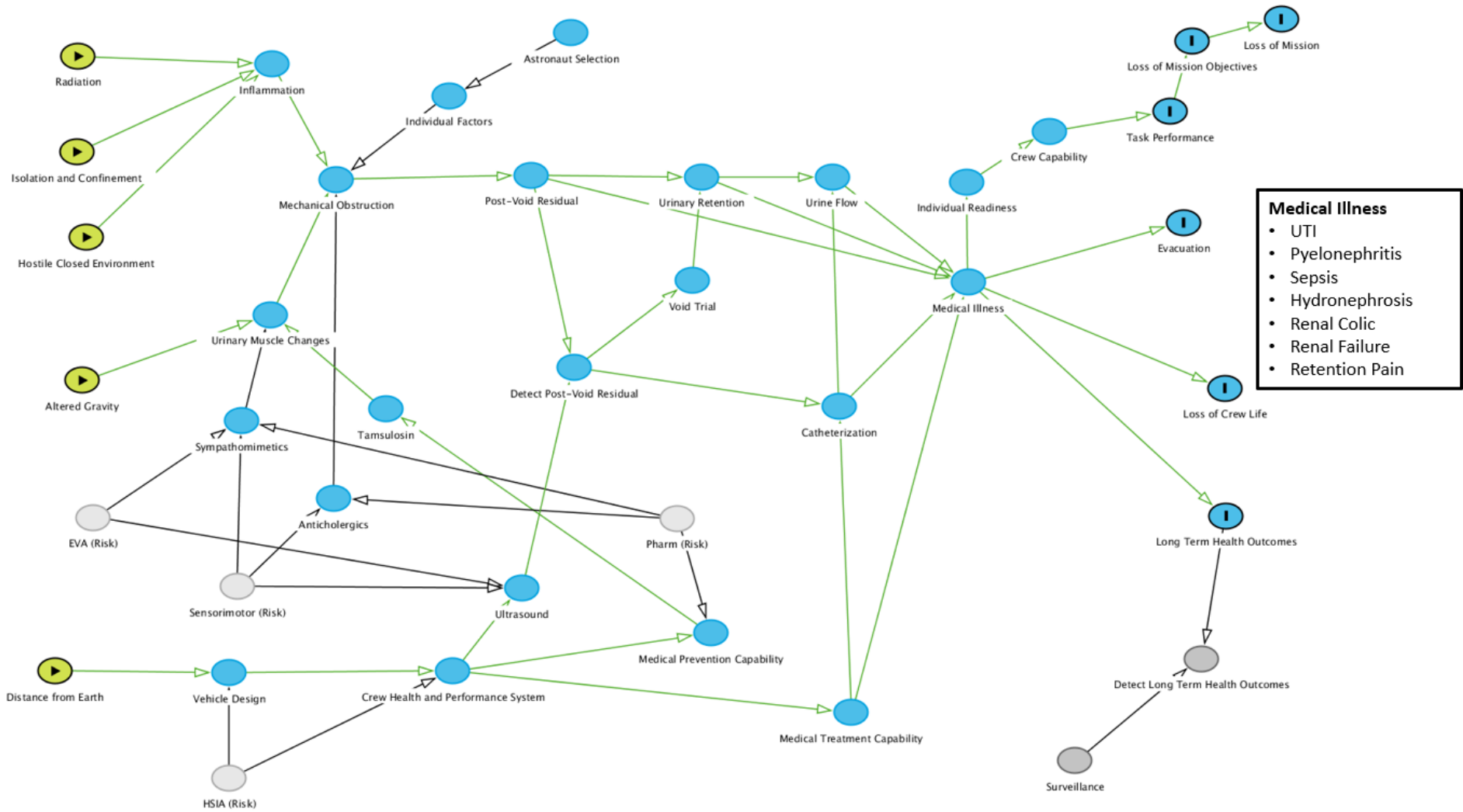
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**Directed Acyclic Graphs: A Tool for Understanding the NASA
Spaceflight Human System Risks**

Human System Risk Board

October 2022

Risk of Urinary Retention (Urinary Retention Risk)



Urinary Retention Risk DAG Narrative

- The central focus of the Urinary Retention DAG begins with the **Urinary Retention** node which is the point at which the retention of urine in an astronaut reaches a clinically significant level. **Inflammation** can result from the hazards of **Radiation, Hostile Closed Environment, and Isolation and Confinement**. Prior to that, astronauts may retain urine that they are not aware of and this is called **Post-Void Residual**. Retention may be intentional in some situations. When retained urine begins to affect **Urine Flow**, this can lead to several Medical Illnesses that can affect **Individual Readiness** and **Crew Capability** including:
 - Infectious processes like **Urinary Tract Infections, Pyelonephritis** (kidney infection) and potentially **Sepsis** if untreated, can result from **Urinary Retention**.
 - Renal Colic, Retention Pain, and Hydronephrosis can result from **Urinary Retention** or **Urine Flow** disruption.
- All of these, if untreated, can potentially lead to **Renal Failure** which has implications for **Evacuation, Loss of Crew Life** and **Long Term Health Outcomes**.
- Retention of urine can be caused by **Mechanical Obstruction** at the level of the urinary bladder or prostate (in men). Retention may also be intentional in some situations (e.g. not wanting to use MAG). Retention is affected by **Individual Factors** like age, sex, and genetic predispositions and can be caused by:
 - **Urinary Muscle Changes** that occur in **Altered Gravity** environments or due to Side Effects of certain medication classes including **Sympathomimetics** and **Anticholinergics** used for **EVA (Risk)** mitigation, **Sensorimotor (Risk)** mitigation, Space Motion Sickness, and congestion.
 - **Inflammation** in the bladder or prostate
- Countermeasures must be designed into the mass and volume allocations for the **Vehicle Design** and **Crew Health and Performance System** to effect risk mitigation. These are affected by the **HSIA (Risk)** and include:
 - **Ultrasound Monitoring** is used to **Detect Post-Void Residual** when increased, and if severe can inform the use of countermeasures such as a **Void Trial**.
 - Medical Prevention Capability such as Tamsulosin can help to relax Urinary Muscle Changes.
 - **Medical Treatment Capability** such as **Catheterization** may be needed to relieve **Urinary Retention** and prevent the development of other **Medical Illnesses**. Other medical treatments may be needed if **Medical Illness** progresses (i.e. **UTI -> Pyelonephritis -> Sepsis**).
- Effectiveness of the Medical Prevention Capability and the Medical Treatment Capability is dependent on the Pharm (Risk).
- **Long Term Health Outcomes** may occur and **Surveillance** is needed post-flight and post-mission to help **Detect Long Term Health Outcomes** and characterize the magnitude of the Long Term Health risk contribution.