

## Urinary Retention Risk Directed Acyclic Graph (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 **EIHSO (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.

