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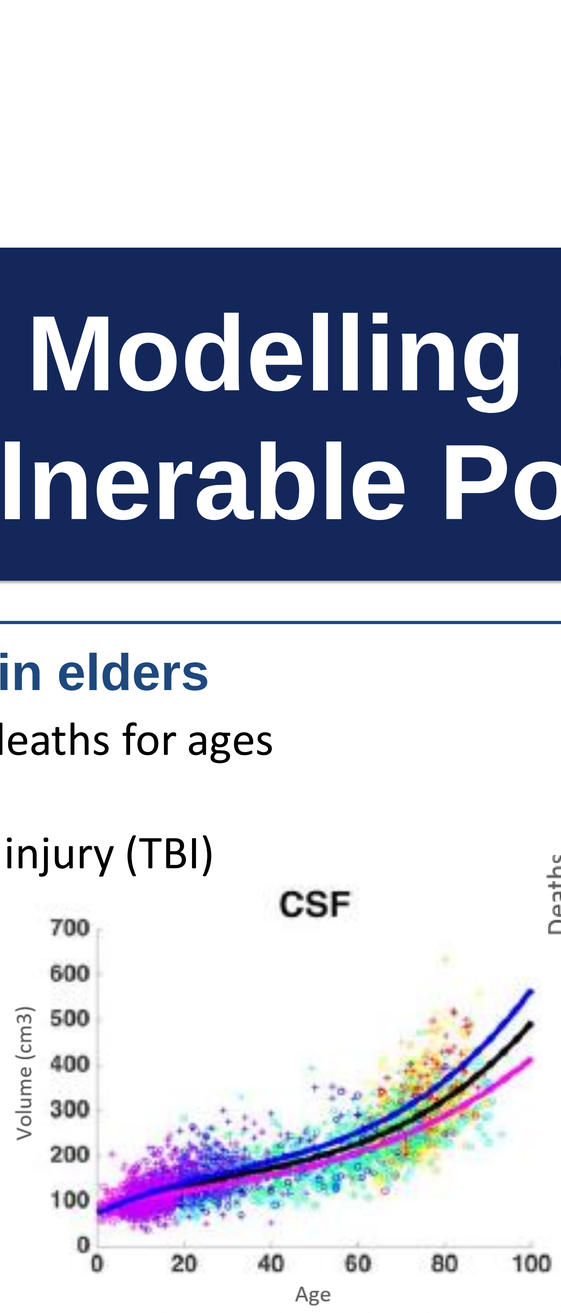
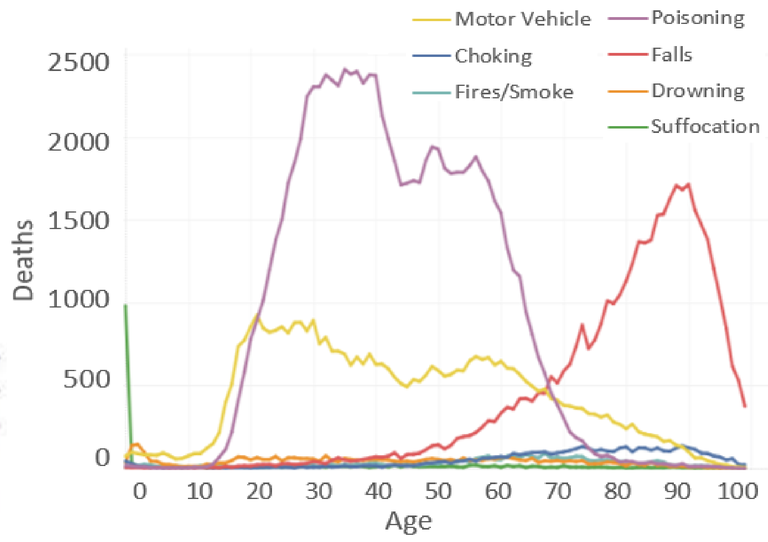
Finite Element Head Modelling of Traumatic Brain Injury in Vulnerable Populations

TBI is the leading cause of preventable death in elders

- Falls are reported as the leading cause of preventable deaths for ages 71+ for the past 14 years [1]
- Fatal injuries due to falls are a result of traumatic brain injury (TBI)
- Brain tissue naturally atrophies with age by ~30-35% in volume at the age of 80, as can be measured by an increase in space around the brain (CSF volume) [2]
- Intracranial volume (space within the skull) remains the same with age, meaning an atrophied brain has more space to move
- Current TBI risk assessment criteria do not account for the increased risk due to increased CSF volume



Volume of Cerebrospinal Fluid (CSF) by Age [2]



Method of Preventable Deaths by Age in 2020 [1]

FEHMs are used to mitigate against TBI, but currently there are none dedicated to elders

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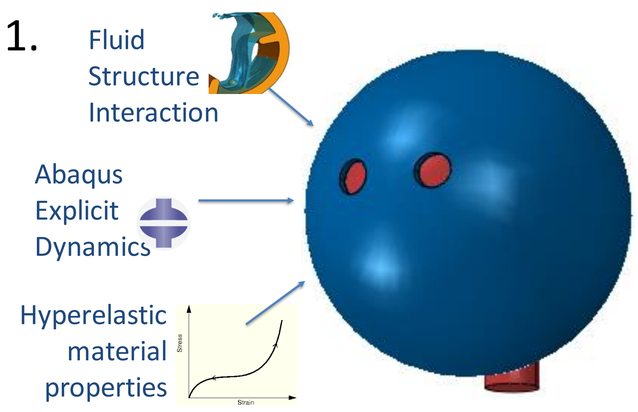

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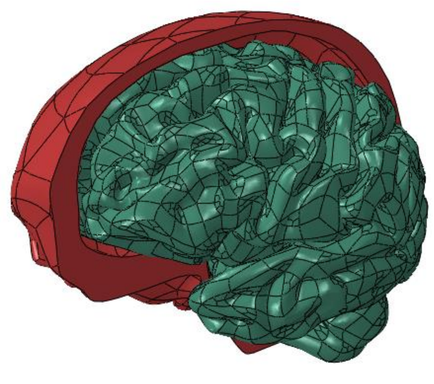

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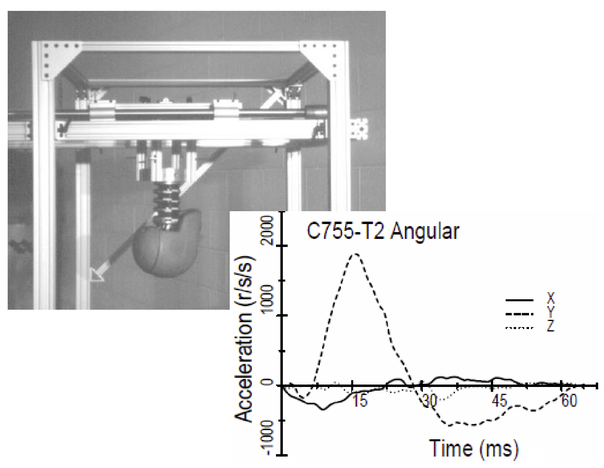

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Aim;

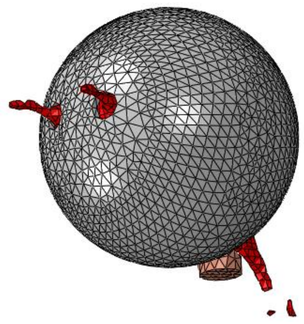
To develop a finite element head model (FEHM) capable of assessing the injury mechanisms of fall induced TBI within vulnerable populations (71+)

Objectives;

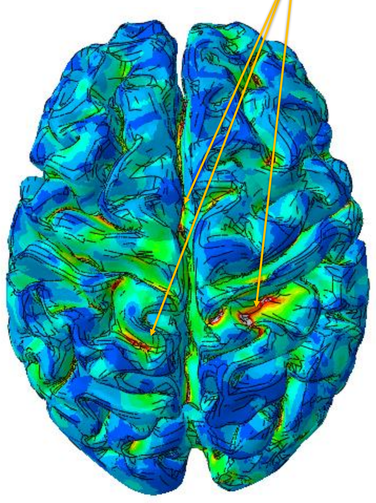
1. Develop a basic FEHM with appropriate physics
2. Build a model with geometry representative of a male elder
3. Validate the model against physical tests published in literature [3]
4. Simulate five scenarios of falls from standing and assess the brain response [4]

Elder and adult brains respond differently

A Coupled Eulerian Lagrangian (CEL) model has been created within Abaqus to prove that it can accurately simulate the behaviour of the cerebrospinal fluid (CSF).



Sulci (damaged regions)

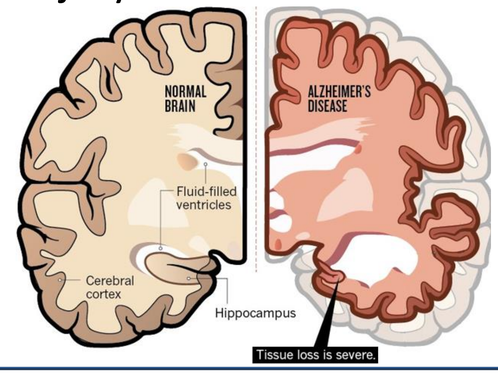


A model representing the natural age-related atrophy of brain tissue was analysed and has indicated high strains in the sulci (grooves) when under load, due to the opening and closing of the gyri (folds) due to the pressure wave. This differs from the response reported in the literature for adult brains where the gyri are more tightly packed and therefore cannot open as easily.

Conclusion and Future Work

- A CEL model within Abaqus is appropriate for modelling the FSI between the CSF and brain/skull
- The anatomical differences between an adult and an elder brain results in different responses under load
- Elder brains are more susceptible to injury than adult brains due to their increased deformations

The model will be developed to investigate whether neurodegenerative diseases further increase the risk of injury due to the increased tissue loss.



References

1 – "Top 10 preventable deaths" *Injury Facts*, vol. 2021, National Injury Council, NIC Injury Facts.

2 – Coupé P, “Towards a unified analysis of brain maturation and aging across the entire lifespan: A MRI analysis”, 2017.

3 – W. Hardy, "Investigation of head injury mechanisms using neutral density technology and high-speed biplanar x-ray“, 2001.

4 – M. Hajiaghamemar, “Measurement of head impact due to standing fall in adults using anthropomorphic test dummies”, 2015.

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