Using Data Science to Identify Injury Risk Levels of Vehicle Passenger Population Segments

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RAMDO® Solutions is a software development and consulting services company focused on developing tools that account for variability in simulation inputs.
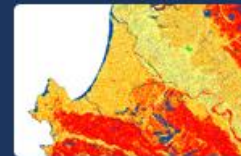
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SIMULATION

INPUT VARIABILITY → RAMDO → OUTPUT VARIABILITY
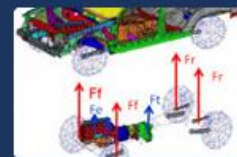
UQ – V&V – RBDO
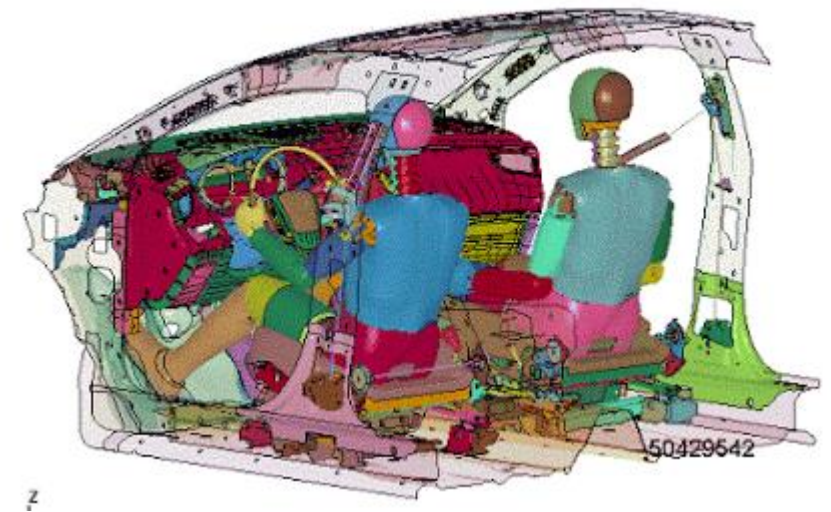
CRASH & SAFETY

MOBILITY MAPPING
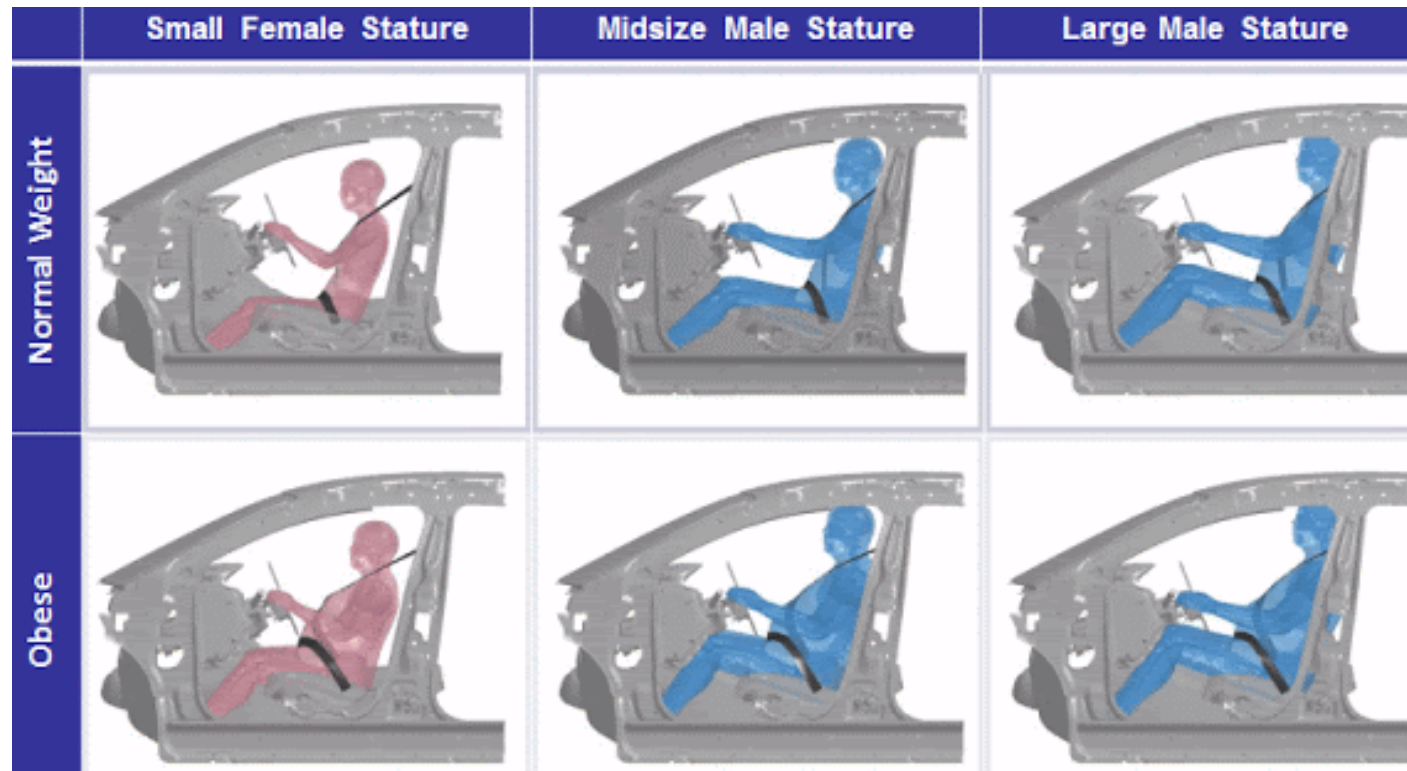
CASTING

NOISE & VIBRATION

DURABILITY & FATIGUE

Challenges of Designing Passenger Restraints

- Physical crash test are expensive.

- People come in many shapes and sizes.

- Computer simulations of crash scenarios are computational expensive to run.
  - Can only run a limited.
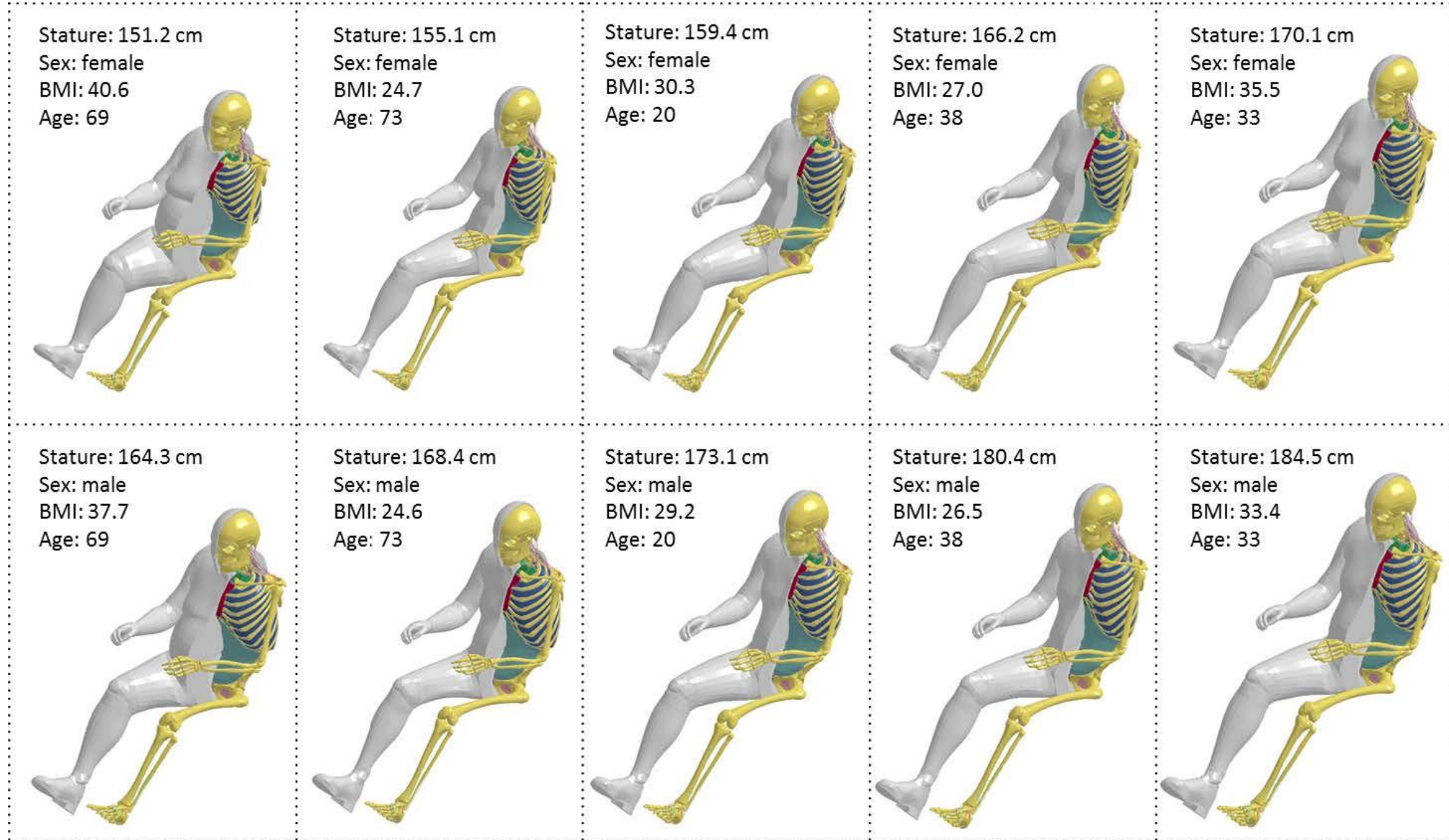 - Cannot simulate the entire driver population.
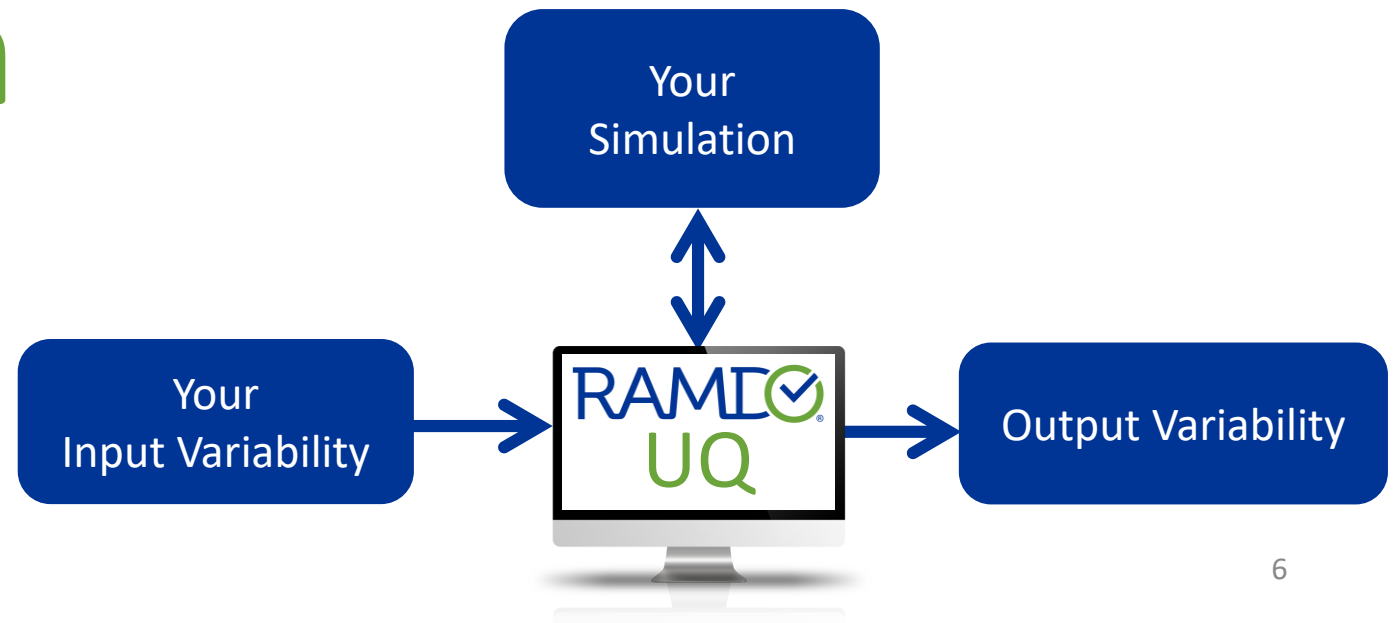
Objective

- Account for the variability the driver population:
  - Gender, age, stature, BMI
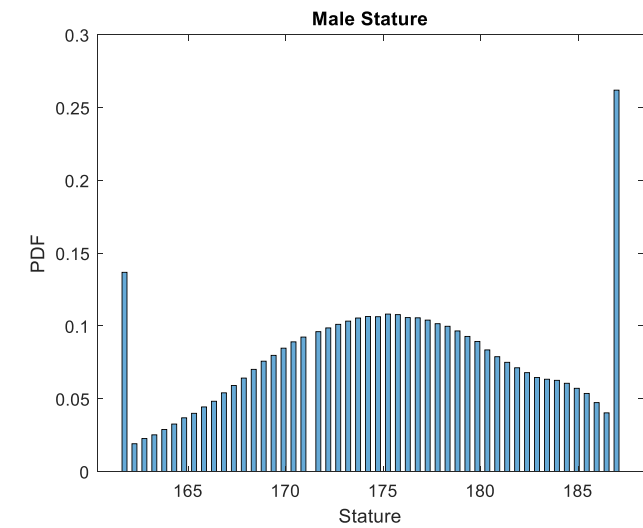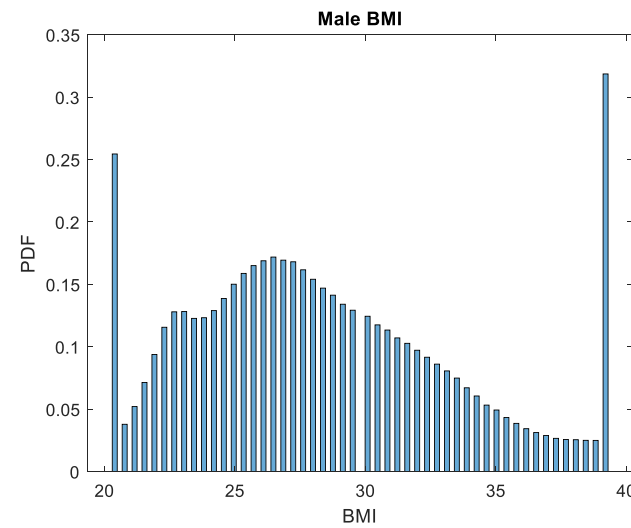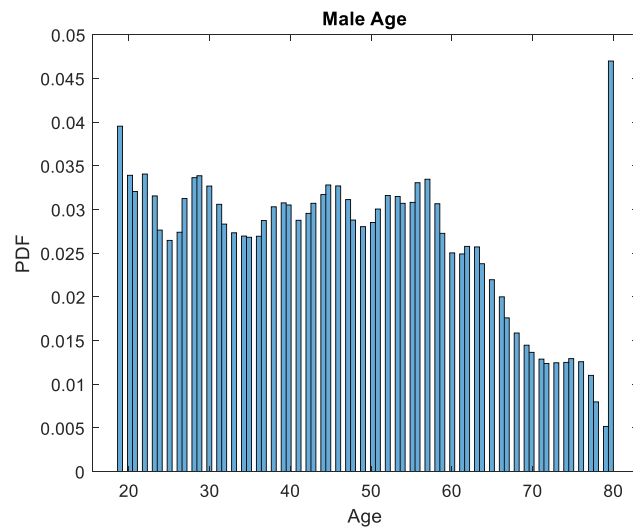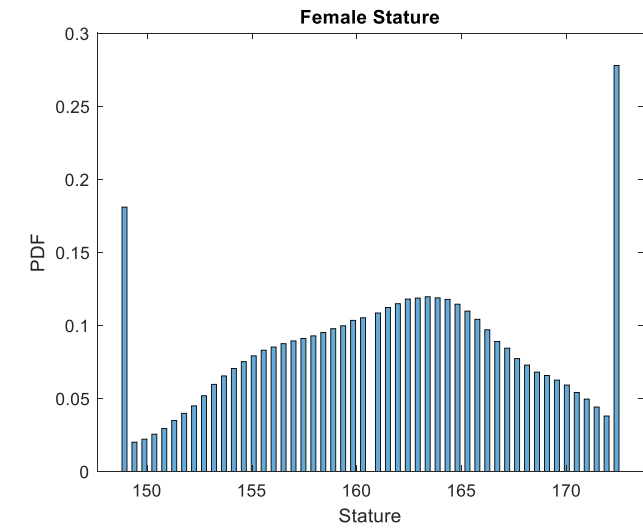- Predict which population segments have a higher injury risk.

Human Driver Population Variability

Stature: 151.2 cm
Sex: female
BMI: 40.6
Age: 69

Stature: 155.1 cm
Sex: female
BMI: 24.7
Age: 73

Stature: 159.4 cm
Sex: female
BMI: 30.3
Age: 20

Stature: 166.2 cm
Sex: female
BMI: 27.0
Age: 38

Stature: 170.1 cm
Sex: female
BMI: 35.5
Age: 33

Stature: 164.3 cm
Sex: male
BMI: 37.7
Age: 69

Stature: 168.4 cm
Sex: male
BMI: 24.6
Age: 73

Stature: 173.1 cm
Sex: male
BMI: 29.2
Age: 20

Stature: 180.4 cm
Sex: male
BMI: 26.5
Age: 38

Stature: 184.5 cm
Sex: male
BMI: 33.4
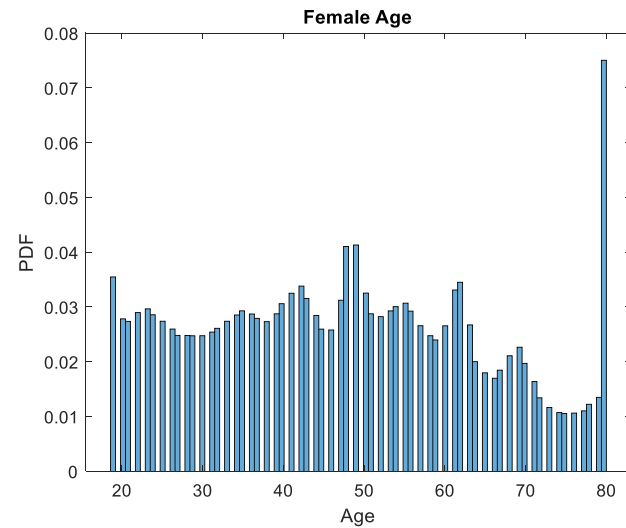Age: 33

Accounting for Human Driver Variability using Uncertainty Quantification

Human Driver Population Variability
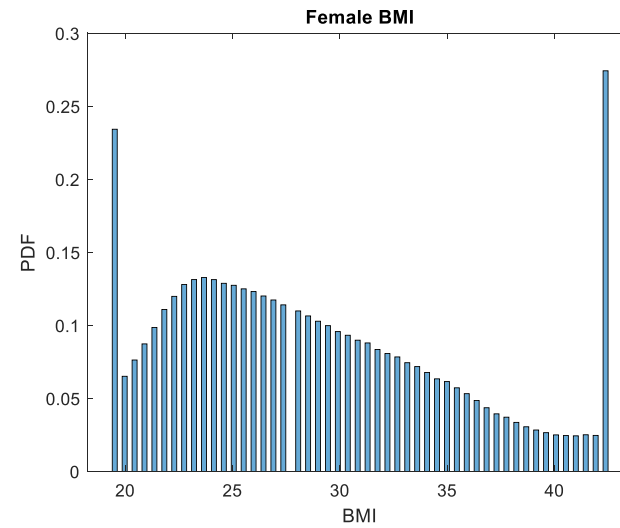
Fryar, C., Gu, Q., Ogden, C., Flegal, K., 2016. Anthropometric reference data for children and adults: United States, 2011–2014. National Center for Health Statistics. Vital Health Stat 3.

UQ for Human Population & Passenger Restraints

Input Variability

External Body Surface Model

22 kg/m² · 26 kg/m² · 30 kg/m² · 34 kg/m²

40 YO

80 YO

Female AgeYear PDF

- Original PDF
- PDF by Realizations
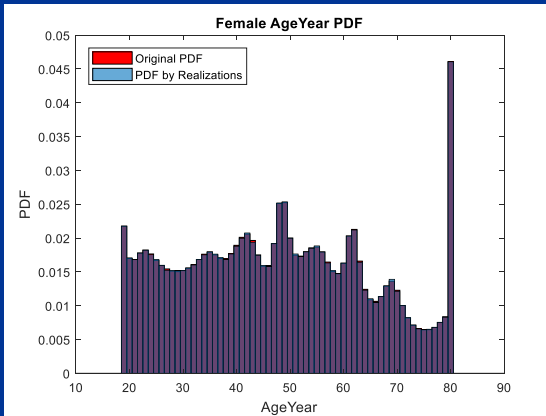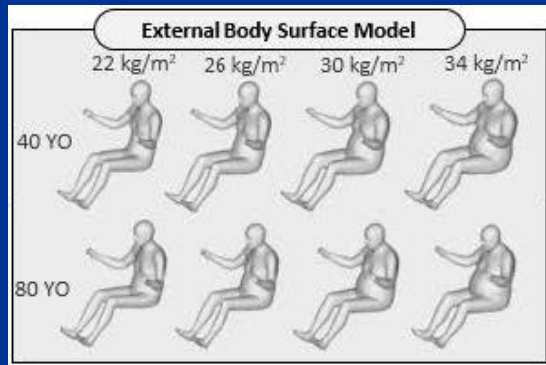
Driver Population: Age, Stature, BMI, Gender

Injury Risk Analysis

- Brute force Monte Carlo
- 1 Million Simulations
- Each simulation takes 4 hours to run.
- Run 100 simulations in parallel.

Takes ≈4.6 years!

UQ for Human Population & Passenger Restraints

Input Variability

External Body Surface Model

22 kg/m²	26 kg/m²	30 kg/m²	34 kg/m²
40 YO			
80 YO			

Female AgeYear PDF
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Driver Population: Age, Stature, BMI, Gender
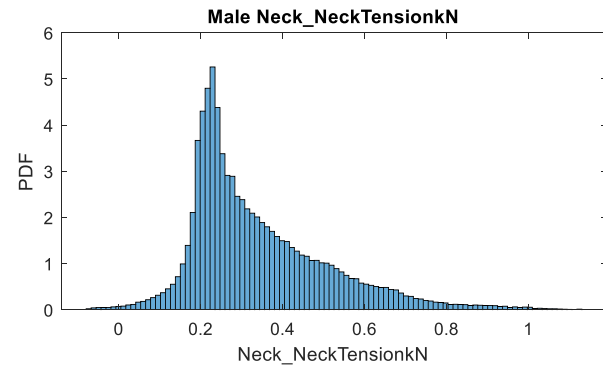
Injury Risk Analysis

RAMDO UQ
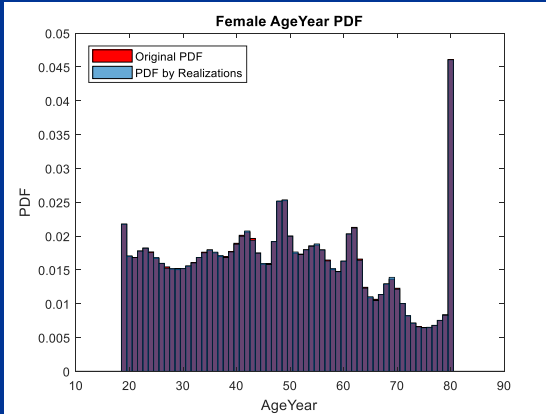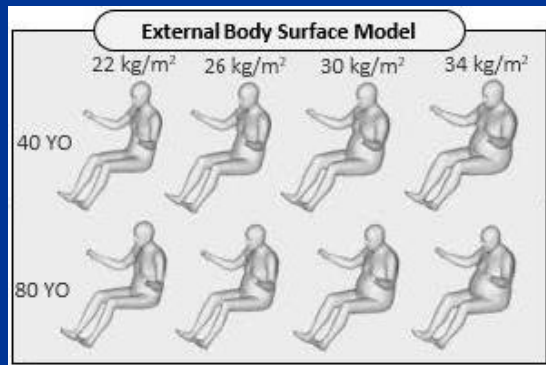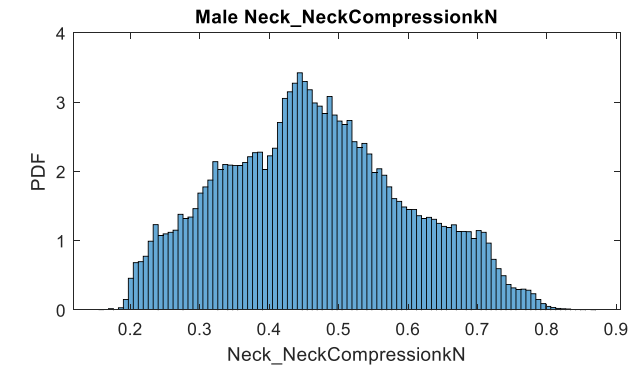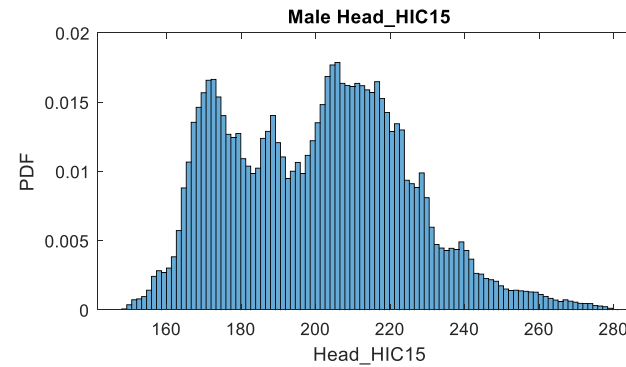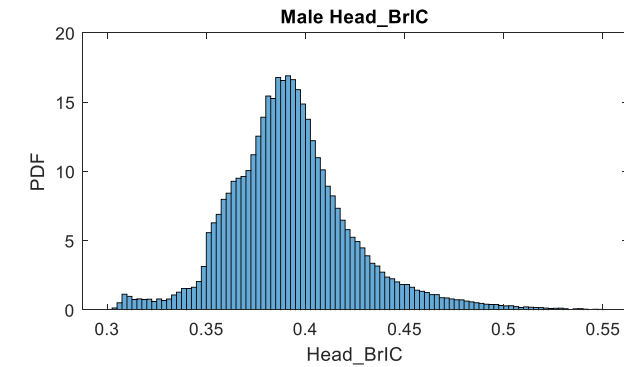
- Need to use UQ
- 100 Simulations (50 male/50 female)
- Each simulation takes 4 hours to run.
- Run 100 simulations in parallel.

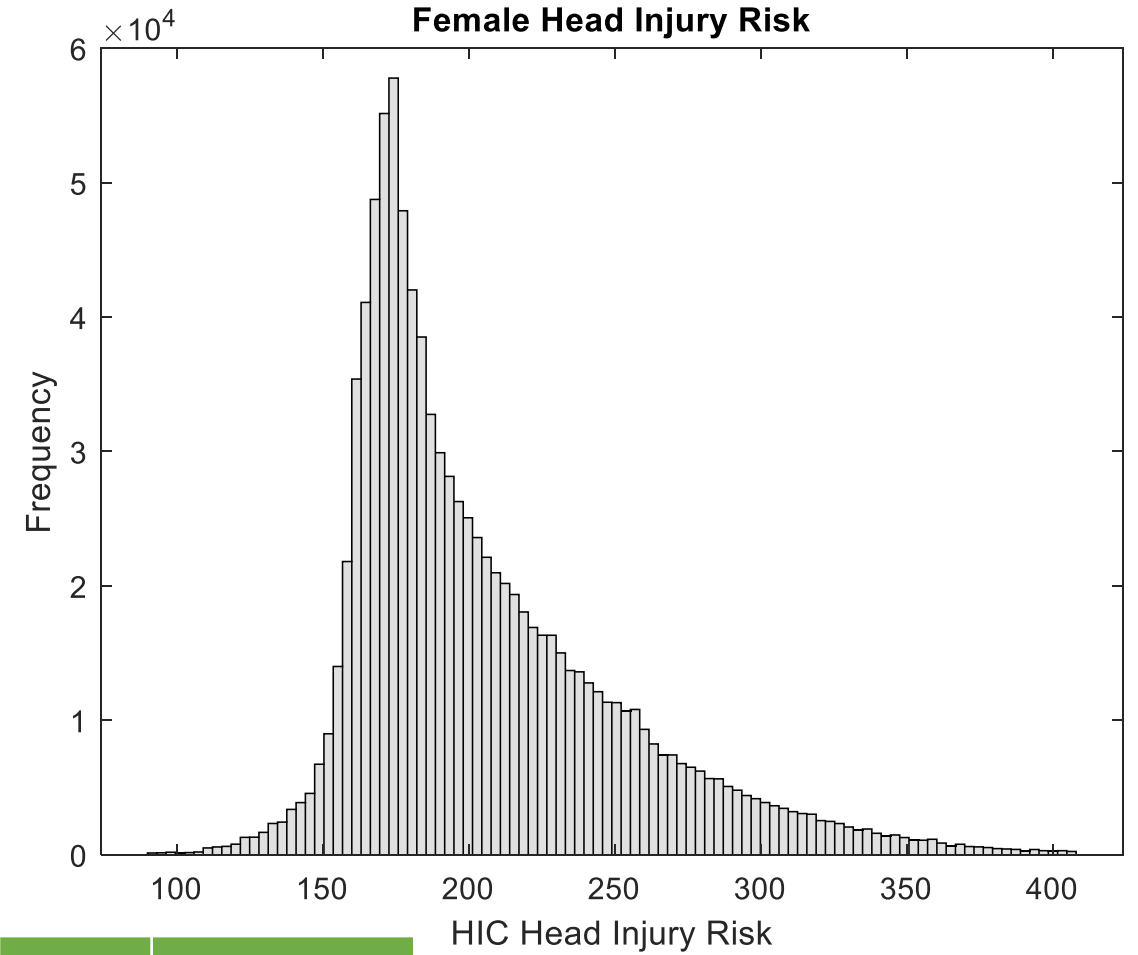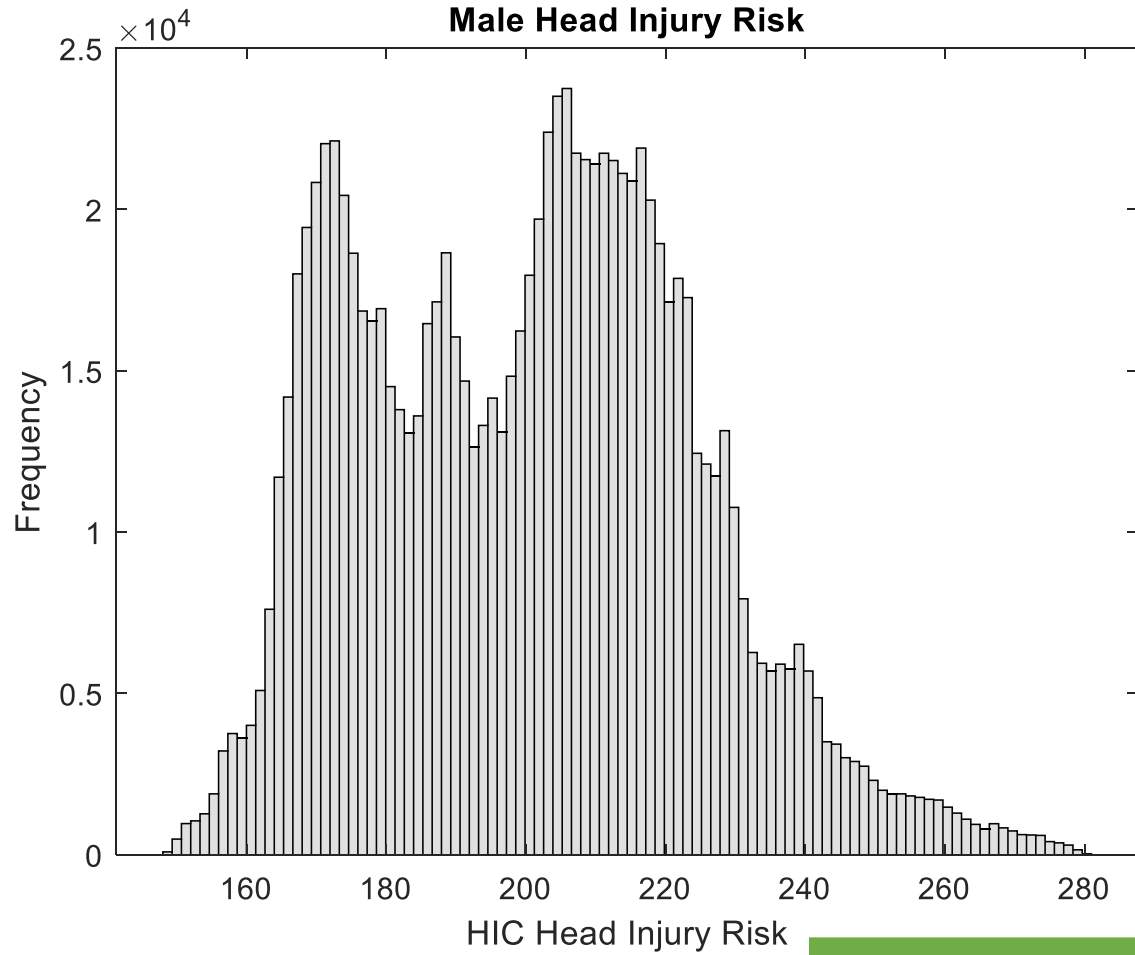**Takes ≈4 hours!**

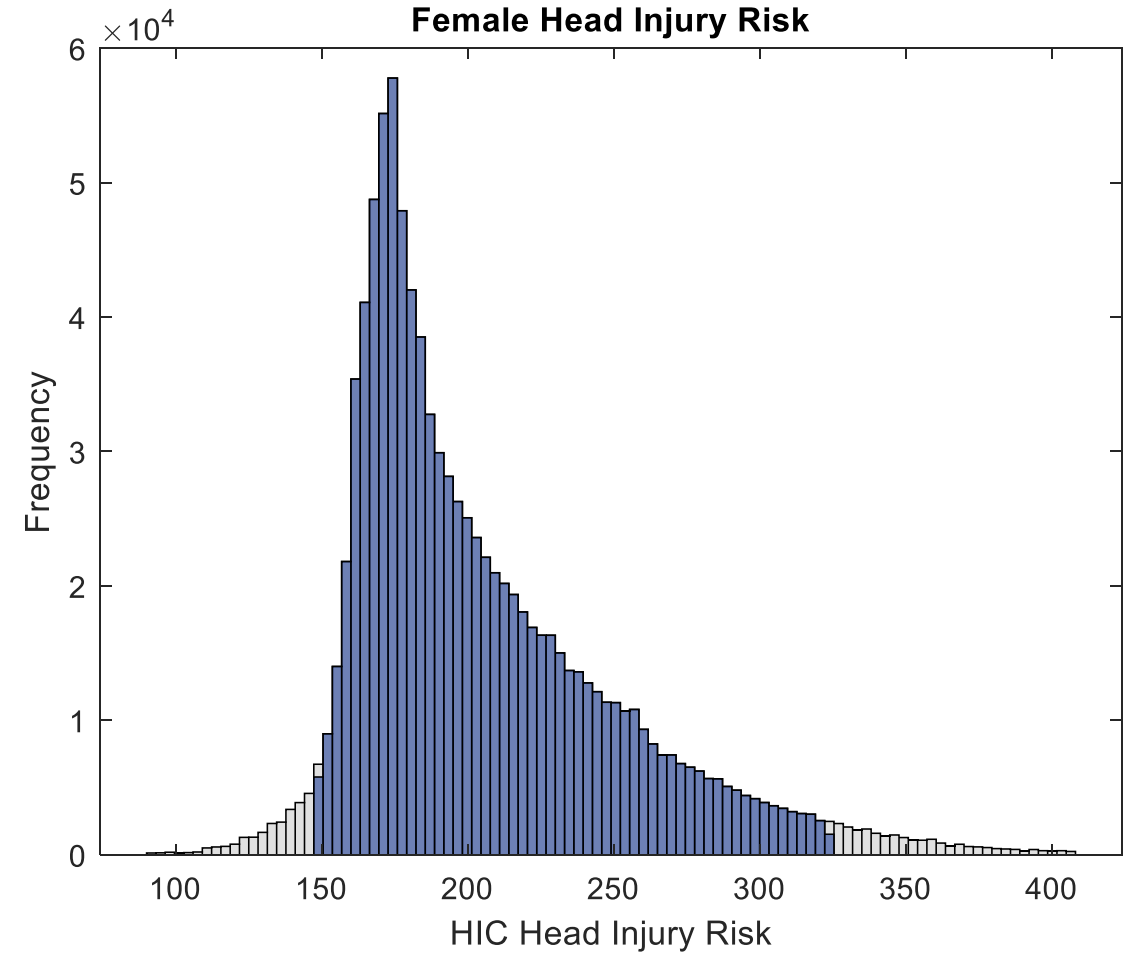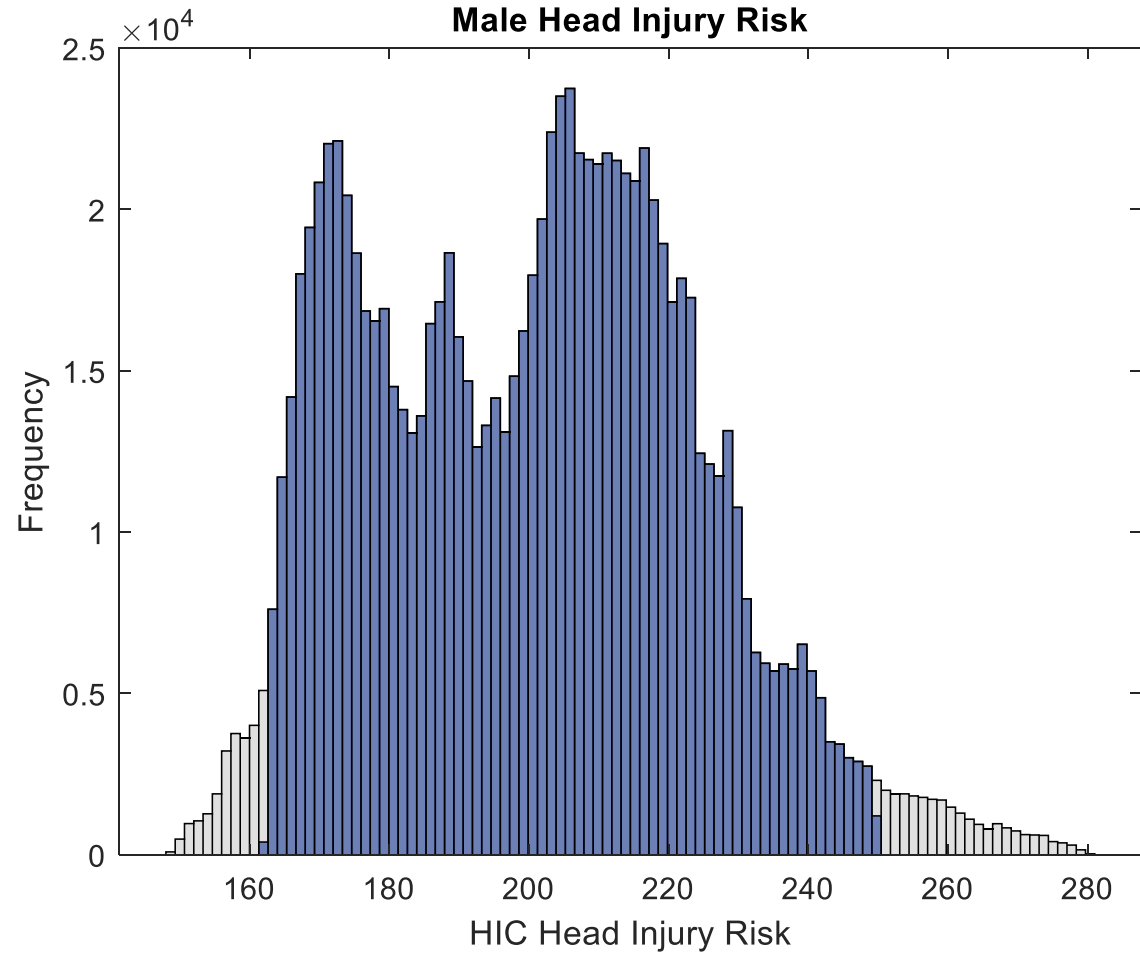# *Female Injury Risk Variability*
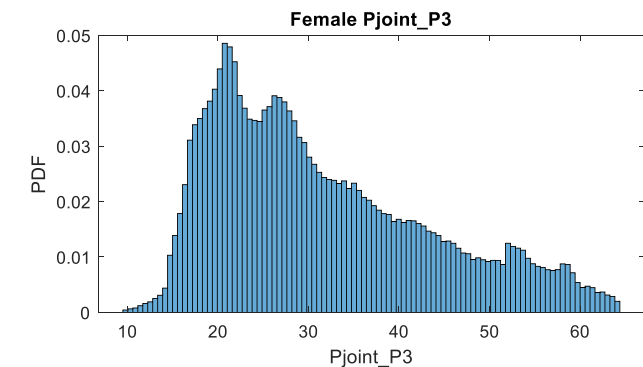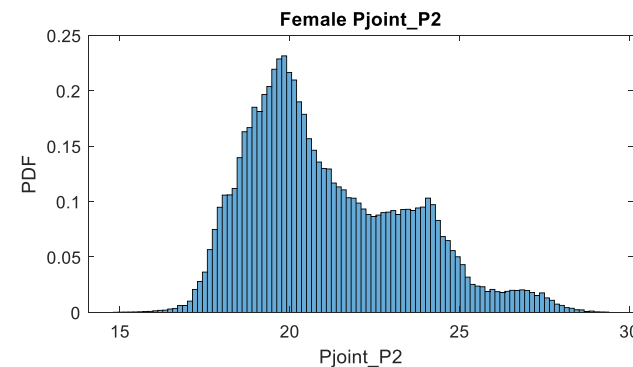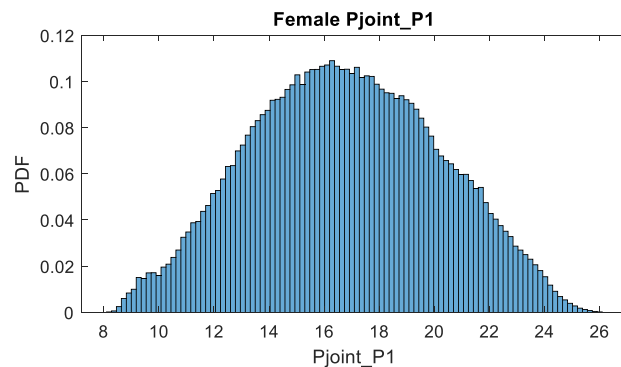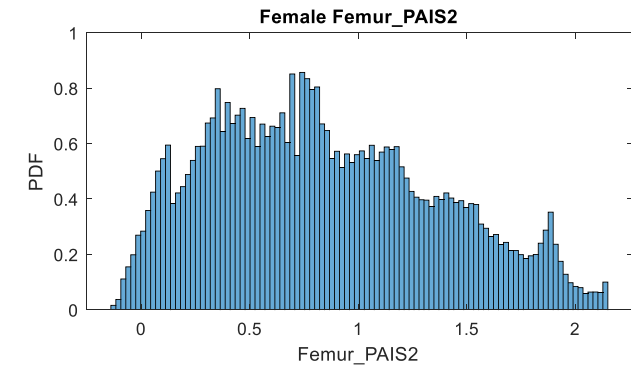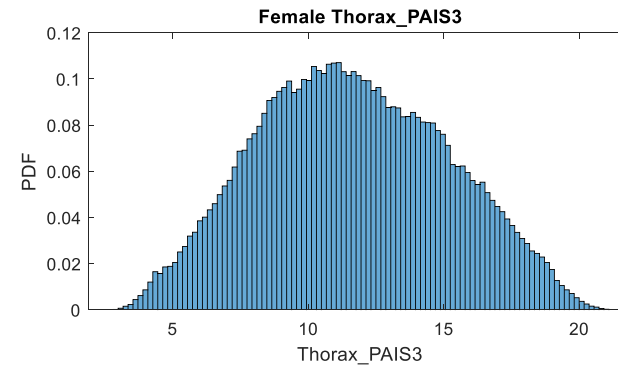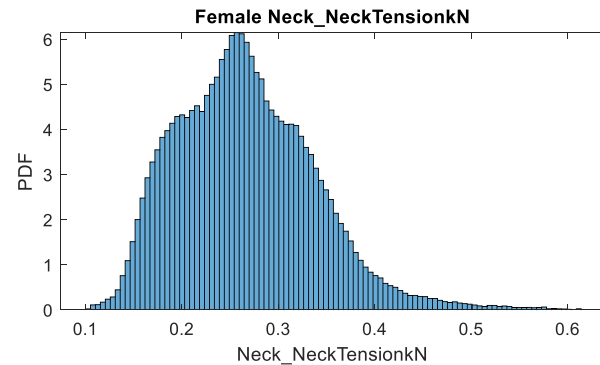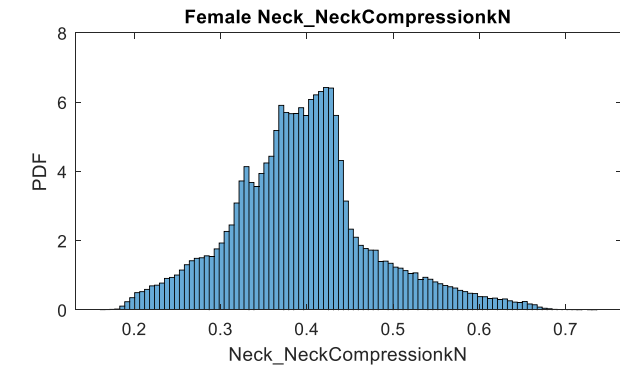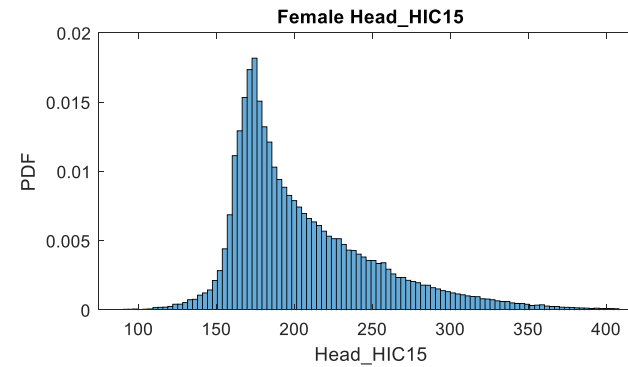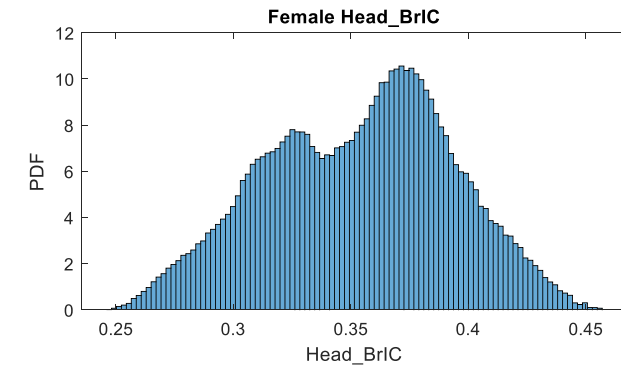
Male Injury Risk Variability
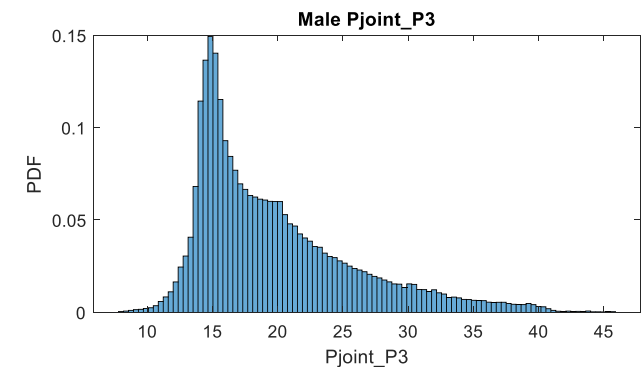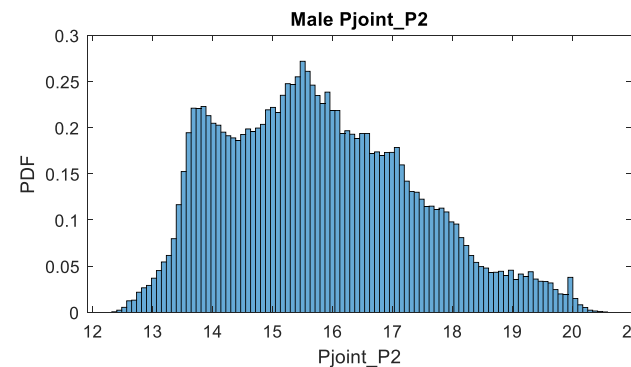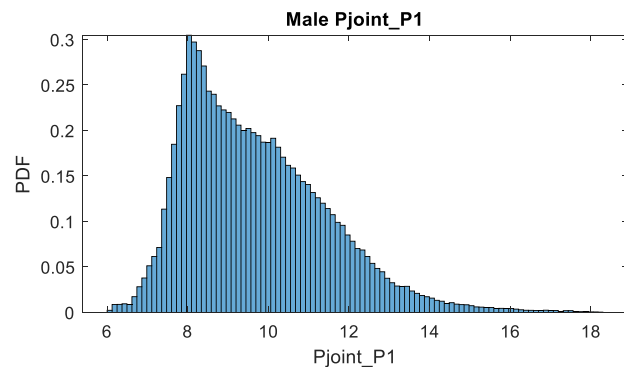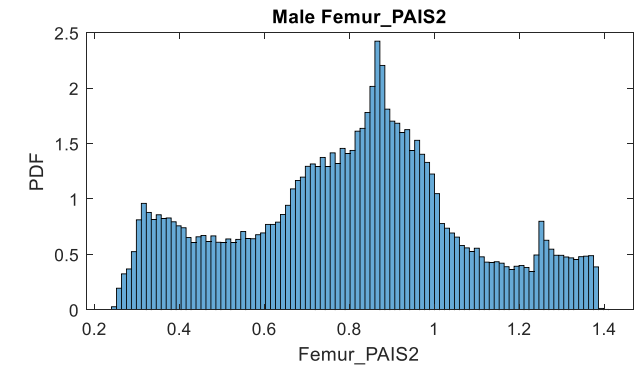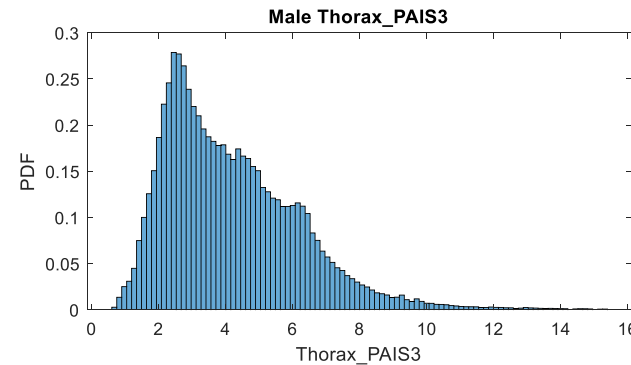
Data Science for Identify Population Segments

Head Injury Risk Variability

	Male	Female
Mean	200.5	205.2
Standard Deviation	23.8	46.0

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Head Injury Risk

Male Head Injury Risk — Frequency ($\times 10^4$) vs HIC Head Injury Risk

Female Head Injury Risk — Frequency ($\times 10^4$) vs HIC Head Injury Risk

	Male	Female
95% Interval	162.6 – 249.7	147.9 – 324.0

Head Injury Risk

Male Head Injury Risk
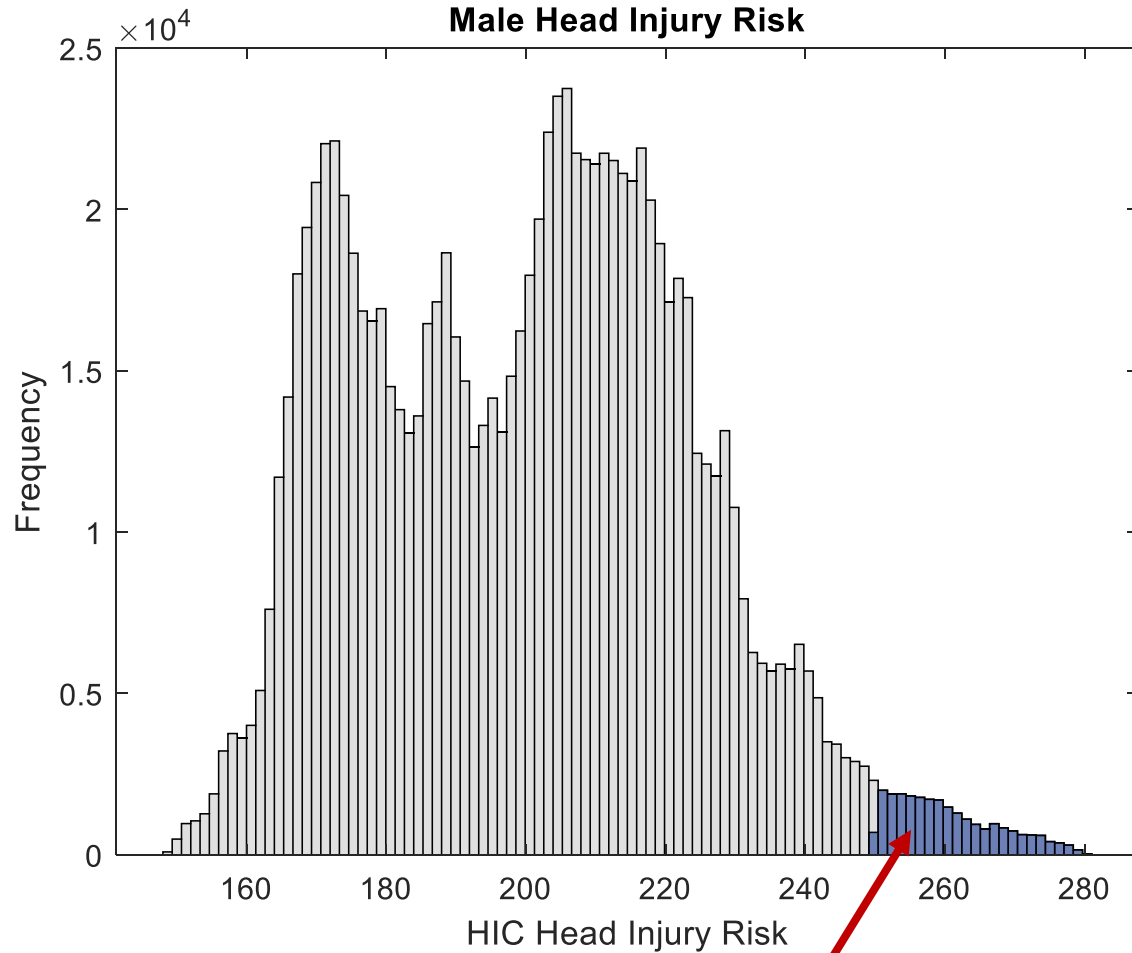
2.46% of Males have Head Injury Risk ≥ 250

Female Head Injury Risk

Who are these females?
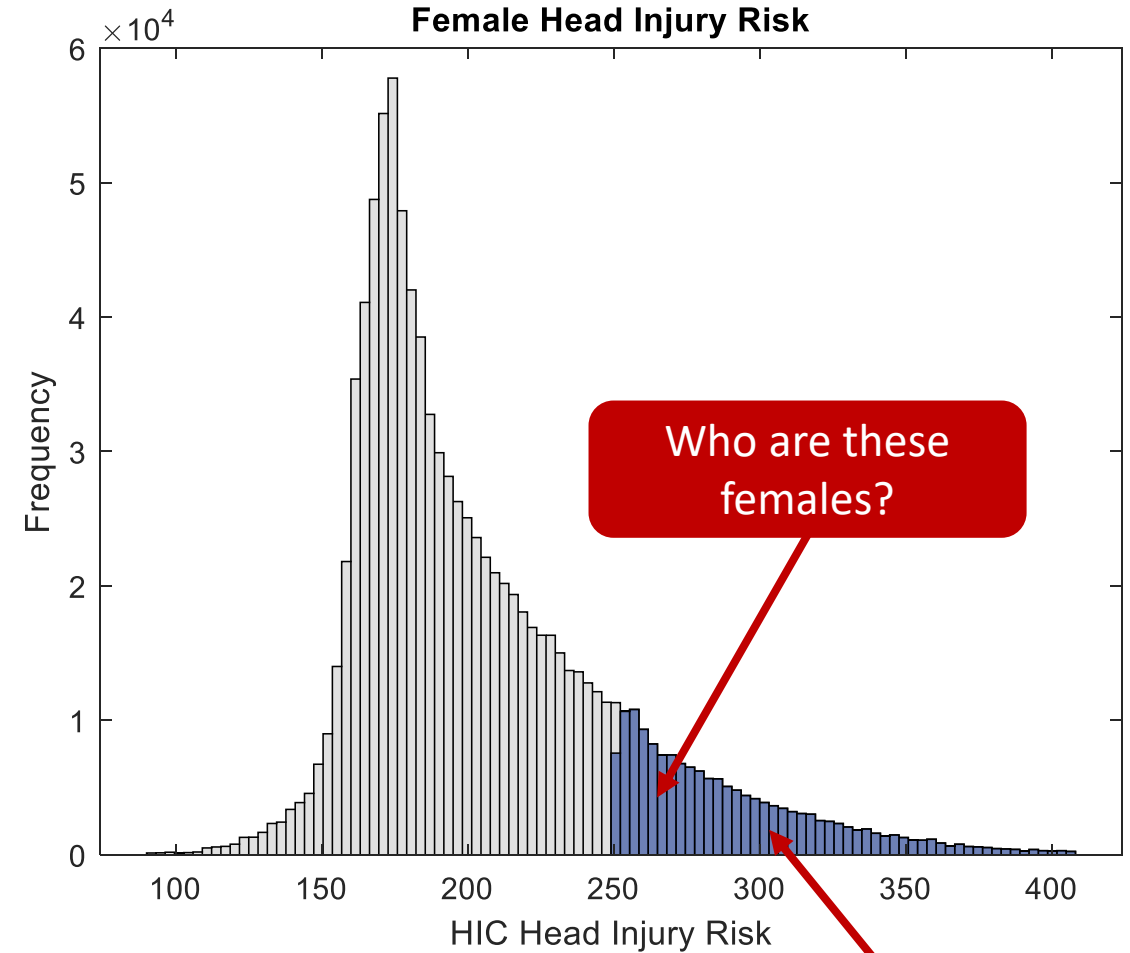
15.98% of Females have Head Injury Risk ≥ 250

High Head Injury Risk Females
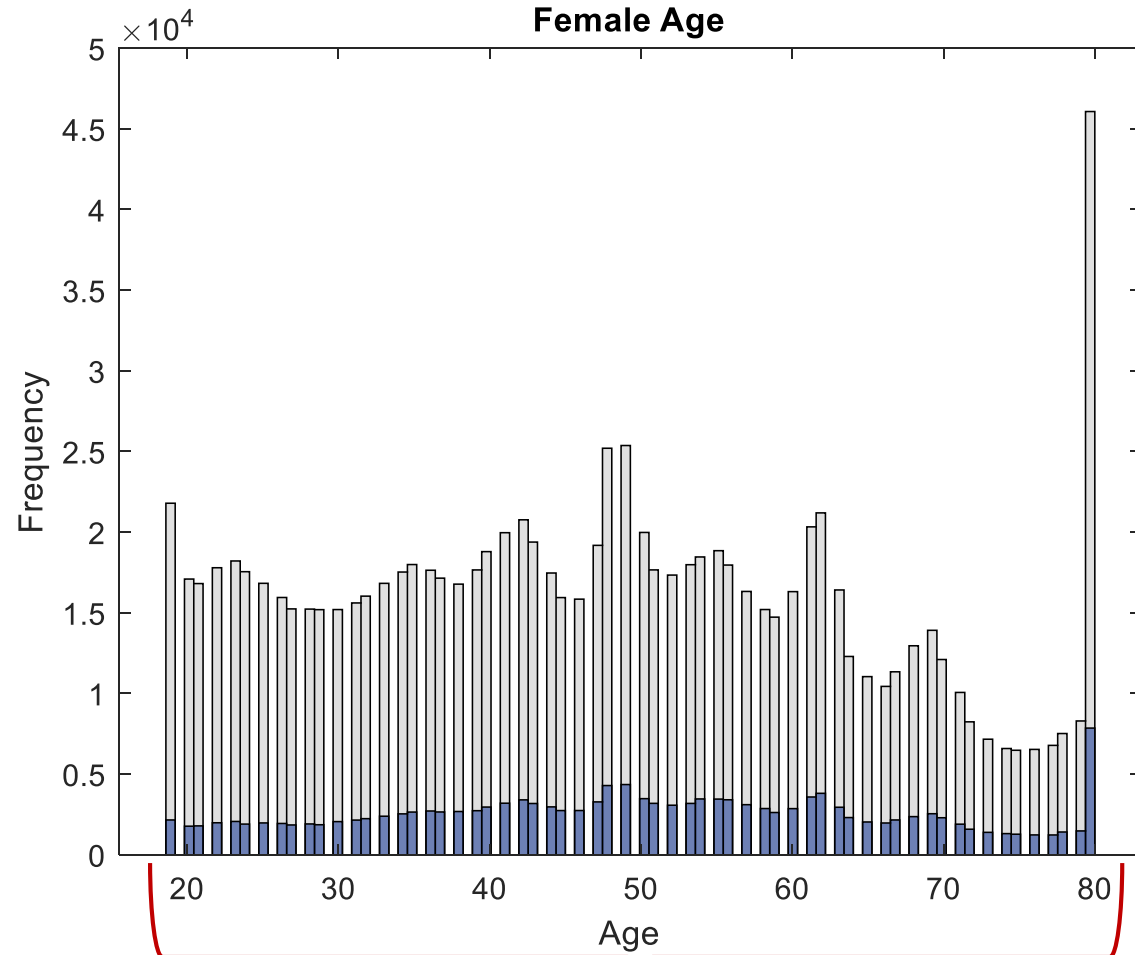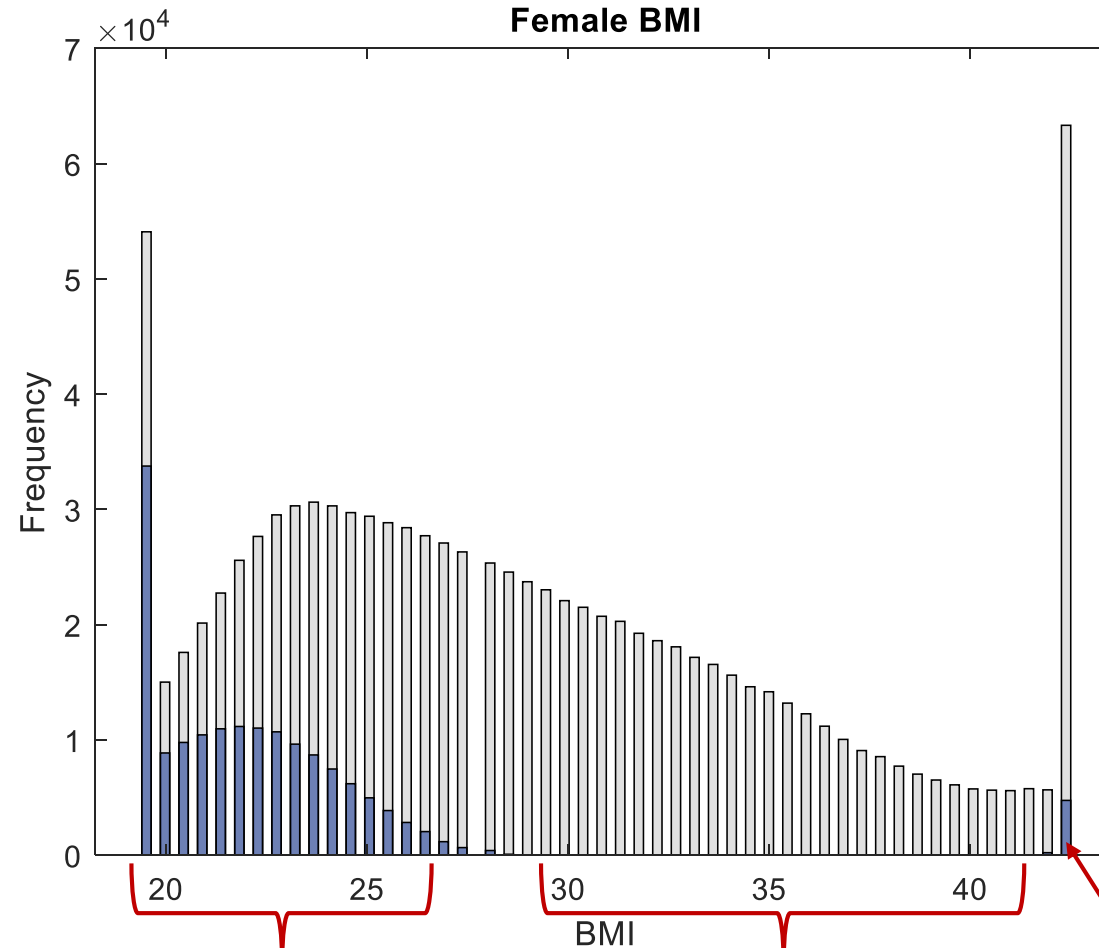

Female Age — Entire age range covered
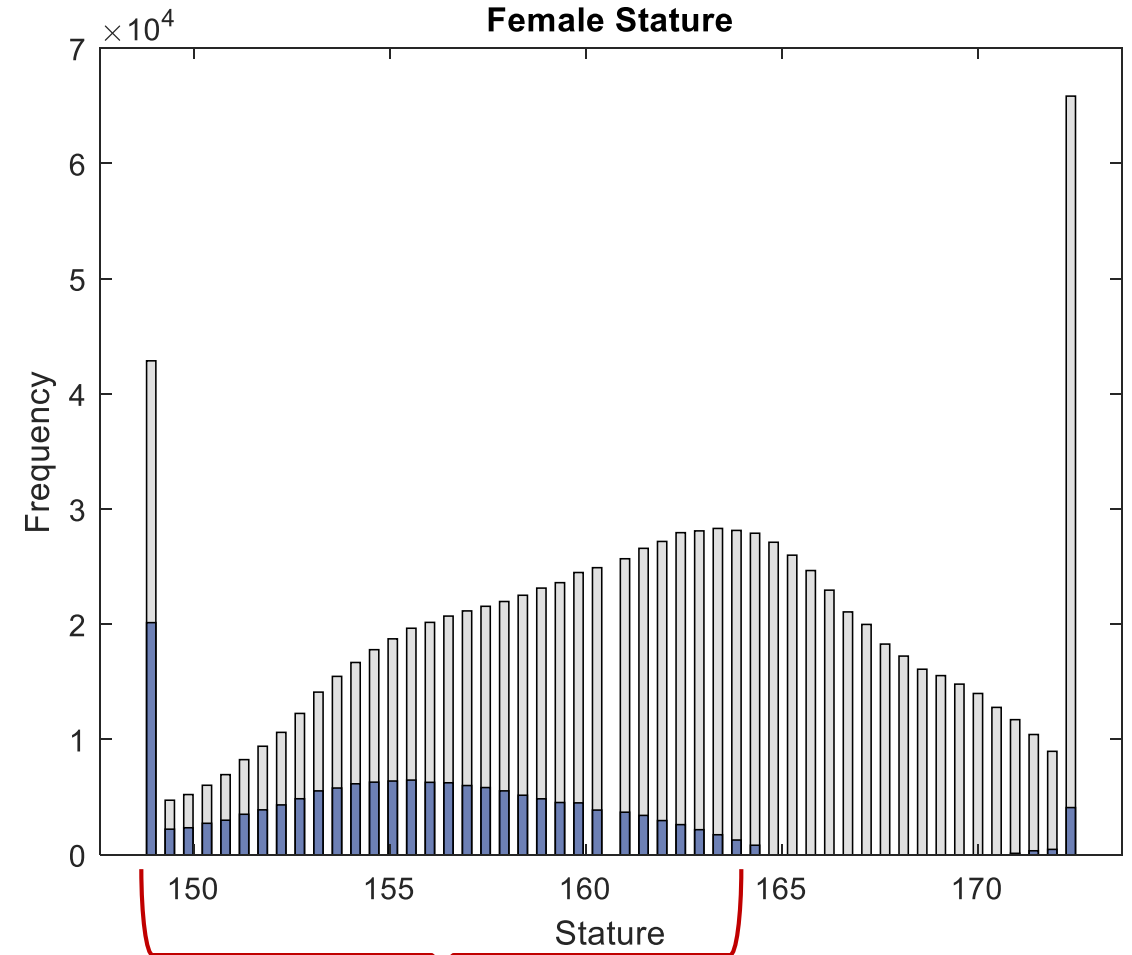
Female Stature — 90% of high risk has stature of 148.8–163.3 cm

High Head Injury Risk Females

Female BMI

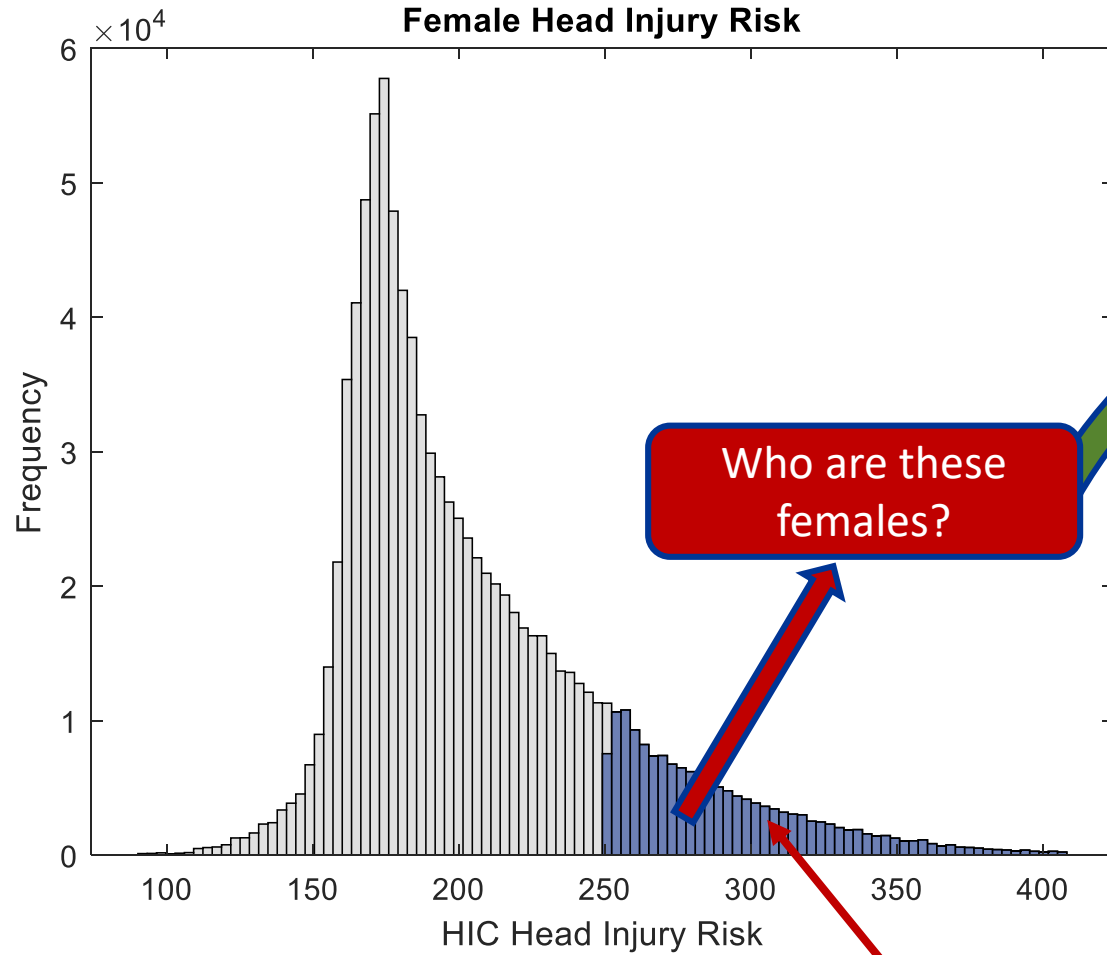90% are in BMI range of 19.5–26.5
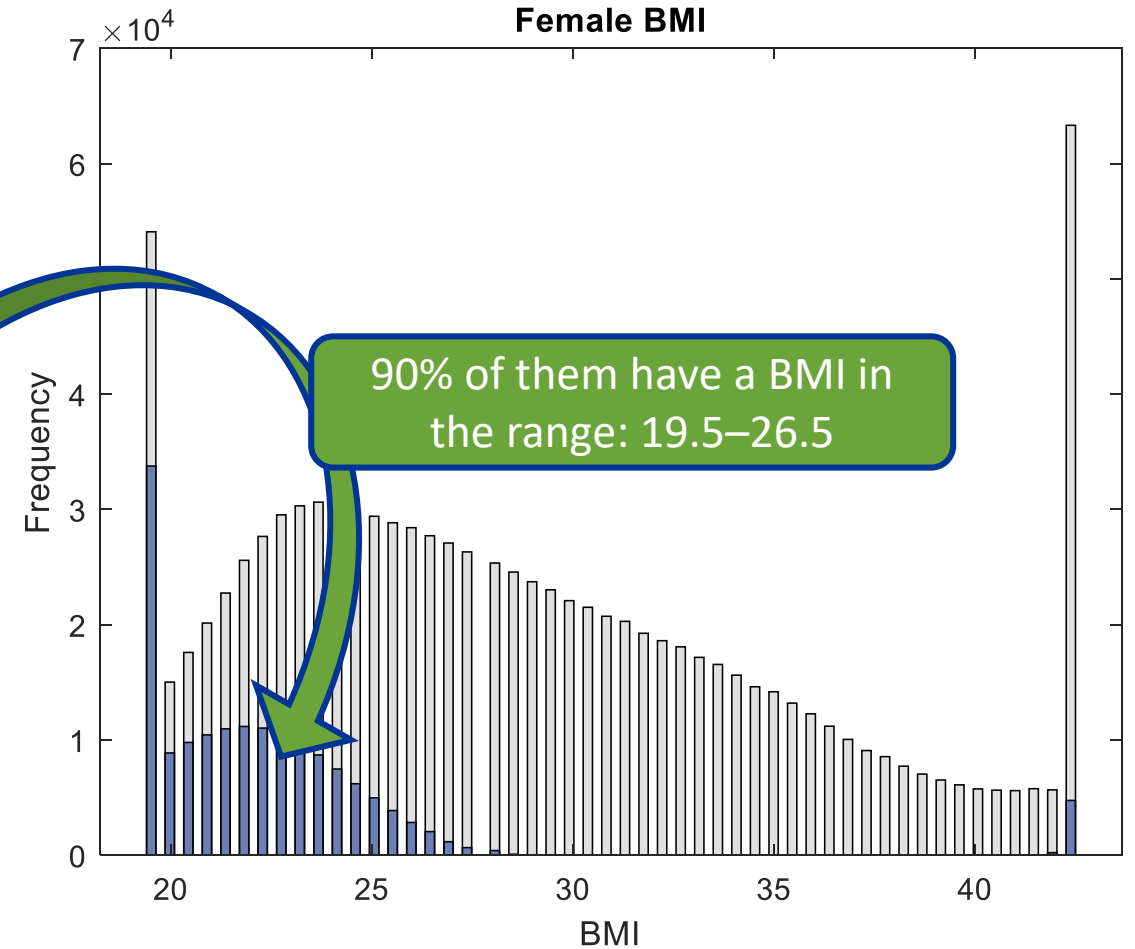
0% are in BMI range of 28.4–42.0

≈3% in Last Bin

High Head Injury Risk Females

Conclusion
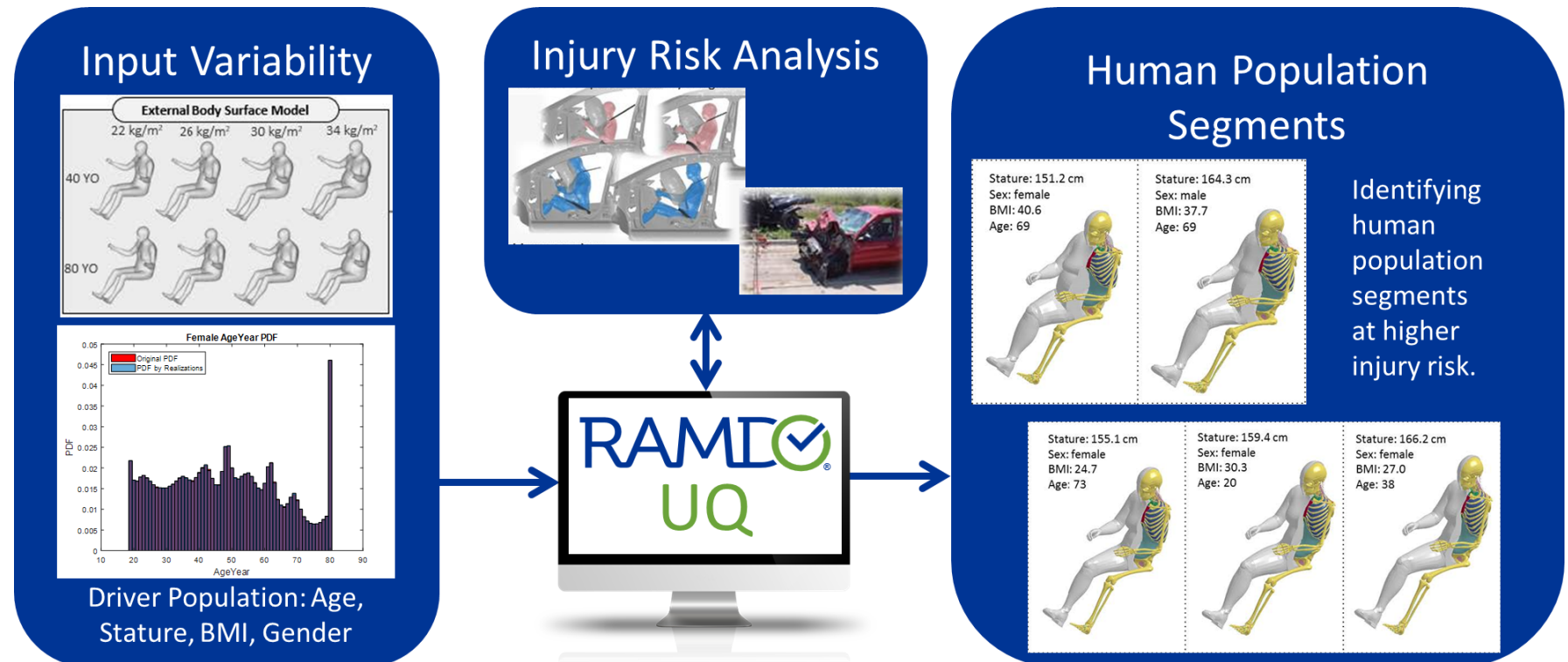
- Uncertainty Quantification (UQ) was successfully used to obtain the variability in the injury risk.
  - 4 hours vs. 4.6 years
- It was shown how data science can be used to analyze all the variability data obtained from UQ and pull out interesting information.

Questions?

Thank You

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Your Simulation

Your Input Variability

The RAMDO Solution