SCIENCE
PASSION
TECHNOLOGY

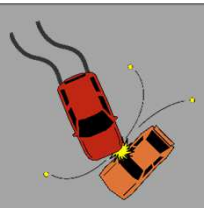
Informal Working Group on Equitable Occupant Protection

TF 5 - Extension to new injury types

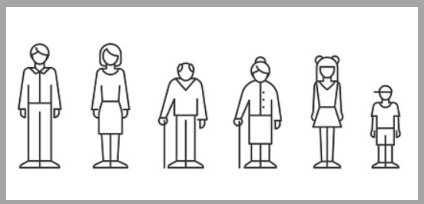
IWG EqOP - TF 5

EqOP Approach

0.) Field data study



Identify which loading scenarios in the field cause significant differences in injury risks for different groups of the population and review how those are currently assessed in regulations



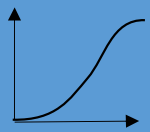
- gender
- age
- body height
- BMI

1.) Use available tools (already currently used in regulations) to address problems identified in 0.)

Change wordings in regulations

Change requirements in regulation with available tools:

a) Change what is required / voluntary?

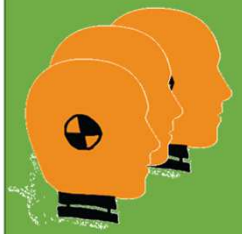


b) Change injury criteria

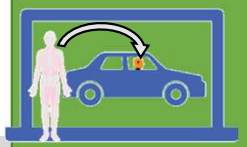
c) Change test conditions (speed, barrier, angle...)

2.) Use alternative test tools to address problems identified in 0.)

Which injury mechanisms can be predicted additionally compared to currently available tools, where problem in the field are observed?



Which alternative physical test tools are suitable for this?



What can be simulated what currently can‘t be tested?

Key take away messages from field data studies

- Injury risk depends on
  - crash severity
  - vehicle crashworthiness (e.g. rating result, vehicle size, age of the vehicle (market introduction))
  - seat position (driver vs. passenger / front vs. rear)
  - age of occupant
  - BMI of occupant
  - gender / sex
  - stature of occupant? (Only available in a few studies)
- Relevance different for different injury and crash types (not one group at highest risk in general) and statistical models applied
- Interaction of parameters often different for females and males
  - Difference between males and females more often reported for younger groups, age distribution for fatality injured occupants
  - Interaction of BMI and gender (different body shapes, fat distributions, belt fits)
  - Crash severity (females more likely to be in smaller and struck car) → **Compatibility not part of the IWG work**
  - Females more likely to be passenger (front and rear)

Summary of Equity Issues (1/2)

Head injuries – different conclusions in different studies; further review also with simulation studies required (many interacting factors and different injury types)

- Significant higher head injury risk for females (Abrams and Bass, 2022 for AIS2+, 3+ and fatalities; Craig et al., 2023 for AIS2+)
- Significant higher risk for brain injuries for females (Antona-Makoshi et al., 2018; Forman et al., 2019)
- Significant higher risk for males (Craig et al., 2023 for AIS3+; Nutbeam et al., 2022 for trapped; Wallbank et al., 2023 for AIS2+ in frontal; Forman et al., 2019 for skull fractures); Higher risk for males (Ostermaier, 2021)
- No significant differences between females and males (Kullgren et al, 2020; Forman et al., 2019 for AIS 4+ brain injuries – BMI and age significant)
- The probability of head injuries decreases for male drivers versus car model year (Ryan and Knodler, 2022)

Neck injuries: several studies agree on higher risk for females

- several studies agree on higher risk for females for (soft tissue) neck injuries; it seems that females have not benefitted as much from protective systems as males with higher risks for younger group (Kullgren et al., 2020 Kullgren et al., 2023, Linder et al, 2032, Kullgren et al., 2010)
- For AIS2+ and AIS3+ significant higher risks for males + significant effect of age shown in the recent NHTSA study (Craig et al., 2023); Extremity injuries (frontal crashes)
- For trapped occupants, significant higher odds of dens fractures (C2) for females (Nutbeam et al., 2022)

Spine: different conclusions in different studies; further review also with simulation studies required (different injury types)

- Higher risk for older occupants (Kullgren et al., 2020; Craig et al., 2023)
- Significant higher risk for females
  - for the spine in general and specifically spinal cord injuries and compression fractures in trapped incidents (Nutbeam et al., 2022);
  - For AIS2+ and AIS3+ thoracolumbar injuries (Craig et al., 2023)
- No significant difference for females compared to males (Kullgren et al., 2020)

Summary of Equity Issues (2/2)

Thoracic injuries: several studies agree on higher risk for older occupants

- Significant higher risk for older occupants (Kullgren et al., 2020, Craig et al., 2023, Wallbank et al, 2023)
- Smaller odd for high BMI (<30) group – significance not evaluated (Craig et al., 2023)
- Significant higher risk for males (Craig et al., 2023, Nutbeam et al., 2023 for trapped)

Abdominal injuries in frontal crashes - different conclusions in different studies; further review also with simulation studies required:

- Higher risk/odds for females (Abrams and Bass, 2022: for young females, Ryan and Knodler, 2022: for rear-end crashes)
- No difference in risk/odds between females and males (Kullgren et al., 2020; Nutbeam et al., 2022, Wallbank et al., 2023)
- Higher risk/odds for males (Craig et al., 2023)
- Age dependent risk/odds (Craig et al., 2023; Wallbank et al., 2023: in frontal crashes; Abrams and Bass, 2022: interaction with gender)
- BMI dependent risk/odds (Craig et al., 2023: lower odds for BMI 30+, significance not evaluated)

Lower extremities – several studies agree on higher injury risk for females; interaction with BMI reported in recent study by IIHS:

- Higher risk for females (Craig et al., 2023: overall, for foot & ankle, leg (only AIS3+); Kullgren et al., 2020; Ryan and Knodler, 2022; Nutbeam et al., 2022: for pelvis; Ostermaier et al., 2021: overall, pelvis; Brumbelow, 2023: interaction with BMI, Wallbank et al, 2023)
- Higher risk for higher age (Wallbank et al, 2023: only for frontal crashes, Craig et al, 2023)

Upper extremities- studies agree on higher injury risk for females:

- Higher risk for females (Kullgren et al., 2020; Craig et al., 2023)
- Higher risk for older occupants (Craig et al., 2023)
- Higher risk for BMI 30+ occupants (Craig et al., 2023: significance not evaluated)

Task Forces for further review of studies and regulations

Increase robustness of assessment in general

1.) TF drafting team on report on equity issues

2.) TF on rear impact seat assessment with focus on soft tissue neck injuries / whiplash associated disorders

3.) TF on Virtual Testing

4.) TF on restraint system requirements

- 3a) geometric requirements for seatbelt
- 3b) dynamic testing requirements / restraint system performance

5.) TF on extension of assessments towards currently not considered injury types with high frequency and risk of PMI

- 4a) Lower extremity injuries in frontal and side impacts
- 4b) Upper extremity injuries in frontal and side impacts
- 4c) Brain injuries in frontal and side impacts
- 4d) Soft tissue neck injuries in frontal and side impacts

Task Force 5: Extension to new injury types

TF on extension of assessments towards currently not considered injury types with high frequency and risk of PMI *(where equity issues have been identified)*

4a) Lower extremity injuries in frontal and side impacts

4b) Upper extremity injuries in frontal and side impacts

4c) Brain injuries in frontal and side impacts

4d) Soft tissue neck injuries in frontal and side impacts

- Explore how these injuries could assessed in regulations
  - review ideas on injury criteria & tools to assess them
    - physical tools (ATDs)
    - virtual tools (HBMs)
  - Discuss and explore how identified knowledge gaps can be closed

Aims of the Task Force

- Review ideas on injury assessments which could be applied to assess currently not considered injuries where equity issues, *high* frequency and *high* risk of longterm consequences have been identified
  - Short term:
    - Apply currently used ATDs
  - Long term:
    - Use HBMs
- Discuss injury types and mechanisms per identified body region
- Discuss countermesures to address the ifentified injury types
- Provide inputs for CBA
- Prepare proposals for short term solutions to assess new types of injuries where equity issues have been identified
- Provide inputs to TF Virtual Crash Testing (TF3) for long term use cases to assess new types of injuries where equity issues have been identified

Who can provide inputs?

UVA: Injury distributions of fine categories within body regions in frontal impacts

TRL: data on lower extremities (frontal)

Folksam: data on different injury types (for different directions)

IIHS: lower extremity injury types in frontal crashes

4a) Lower extremity injuries in frontal and side impacts

UVA: simulation works on ankle injuries in frontal crashes (towards the end of this year)

Review at ISO on biomechanical data for injury criteria

IIHS: correlation of ATD outputs with injury risk

4b) Upper extremity injuries in frontal and side impacts

TRL: report on nature of the injuries

Chalmers: THOR development? HBM development on upper extremities

Autoliv: Shoulder and wrist injuries

4c) Brain injuries in frontal and side impacts

KTH: mechanism specific injury criteria (with relationship to PMI)

4d) Soft tissue neck injuries in frontal and side impacts

Chalmers: Research on soft tissue neck injuries in frontal and side impacts

Time frames for different body regions – to be discussed

4a) Lower extremity injuries in frontal and side impacts

→ Mid term

4b) Upper extremity injuries in frontal and side impacts

→ Long term

4c) Brain injuries in frontal and side impacts

→ Short tem

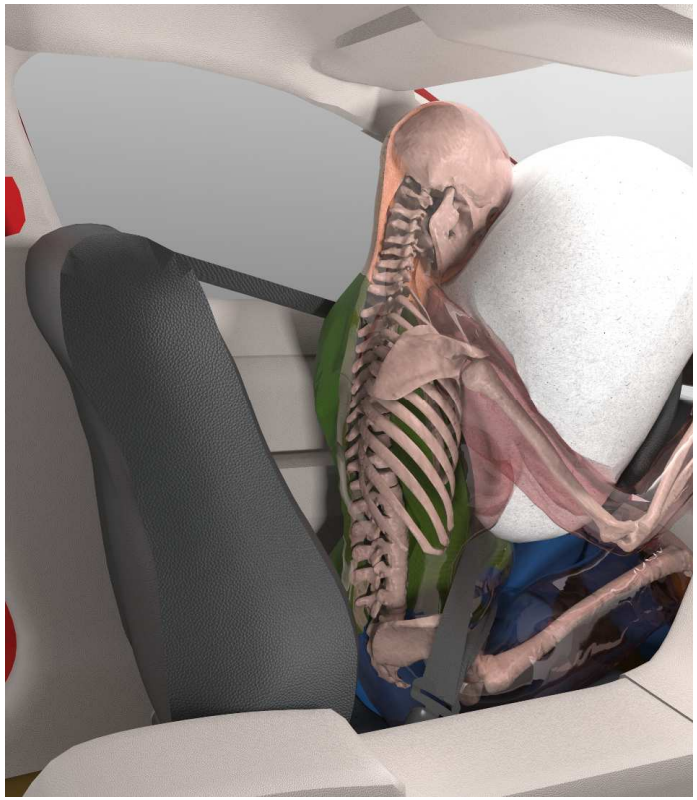
4d) Soft tissue neck injuries in frontal and side impacts

→ Long term

Next meeting(s)

18th of September 12:00-14:00 CEST

2nd of October 12:00-14:00 CEST



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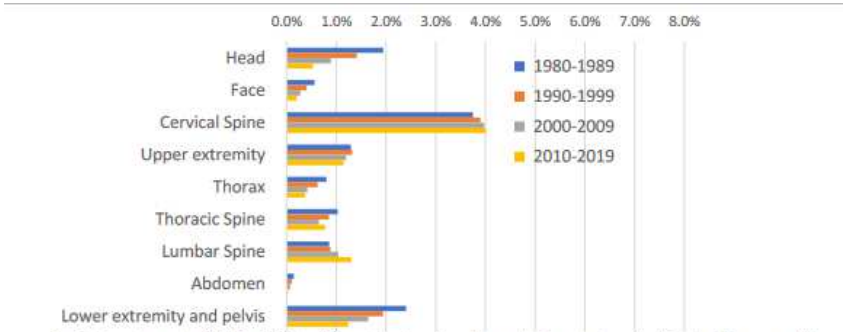

Fig. 4. Development of risk for PMI to different body regions for males for cars launched for the 10-year periods 1980–89 to 2010–19.

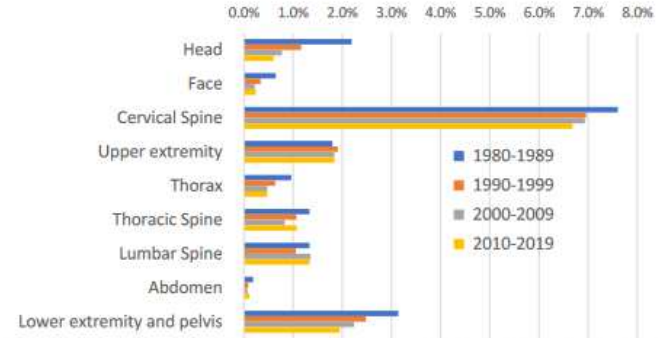

Fig. 5. Development of risk for PMI to different body regions for females for cars launched for the 10-year periods 1980–89 to 2010–19.

Kullgren et al., 2020 http://www.ircobi.org/wordpress/downloads/irc20/pdf-files/14.pdf