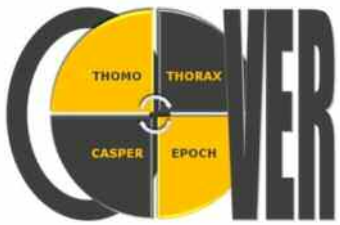
Thoracic Injury Assessment for Improved Vehicle Safety

“COVER”

Coordination and Support Action FP7



Frontal Impact Information

Meeting: GRSP Informal Group on Frontal Impacts
Date of Issue: 27 April 2010
Prepared by: Jolyon Carroll

Introduction

- These accident analyses come from two projects and three specific tasks
- Most of the information relevant to this group will come from the COVER in-depth, statistical, review of accident cases
- Findings are generally supported by later more detailed analysis of cases, in THORAX
  - Throughout the presentation there are remarks from THORAX which support or extend the COVER project findings

Project Overview – COVER

- Aim - to accelerate improvements in biomechanical tools for the design and evaluation of vehicle crash safety systems
- Implementation and coordination of four research activities dealing with human physical (biomechanics) aspects
  - CASPER
  - EPOCh
  - Thorax
  - THOMO

COVER – Task 1.2

Overview of real world thoracic injuries

- This task performed an in depth accident study and provided detailed information on the type and severity of injuries in relation to:
  - Impact type (severity, overlap, intrusion)
  - Restraint type (airbag deployment, load limiter, pre-tensioner)
  - Occupant characteristics (age, size, sex)
- Based on UK (CCIS), German (GIDAS), and French (GIE RE PR/LAB) data
- Frontal impacts, 2000 or newer vehicles, seat-belted occupants, > 12 years-old, etc.

- The results serve as the basis for the activities in both THOMO and Thorax.

Project Overview

Content

General objectives

- Develop required understanding in thoracic injury mechanisms
- Implement this into numerical and experimental tools that will enable the design and evaluation of advanced vehicle restraint systems that offer optimal protection for a wide range of car occupants

Task 1.1

Content

Differences between accidents and crash test results

- Identify whether real-world accident outcomes differ from those expected based on Euro NCAP results
- If so, identify whether occupant factors (age, sex, stature...) are important causes of the differences
- Comparison between Euro NCAP test results and real world accidents
- 20 CCIS cases; 14 GIDAS cases
- GIE RE PR looked further into load-limiter effectiveness

Task 1.2

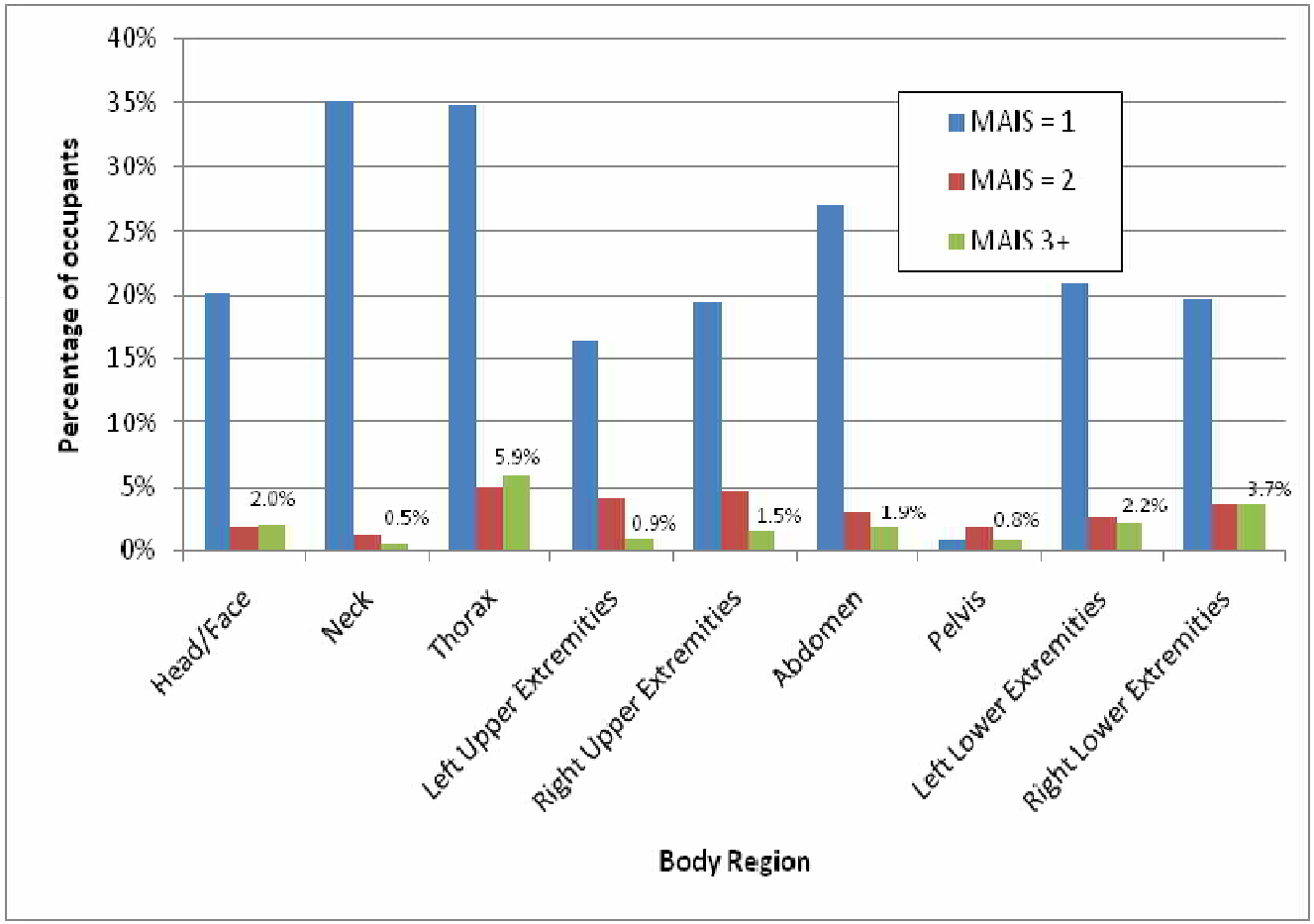
Content

Estimate of the potential injury reduction benefit from introducing an improved thorax and shoulder complex for different occupant sizes and ages

- Using the results from the COVER task and THORAX Task 1.1
- Estimate of total benefit expected from thorax hardware and injury risk functions
- Not completed yet

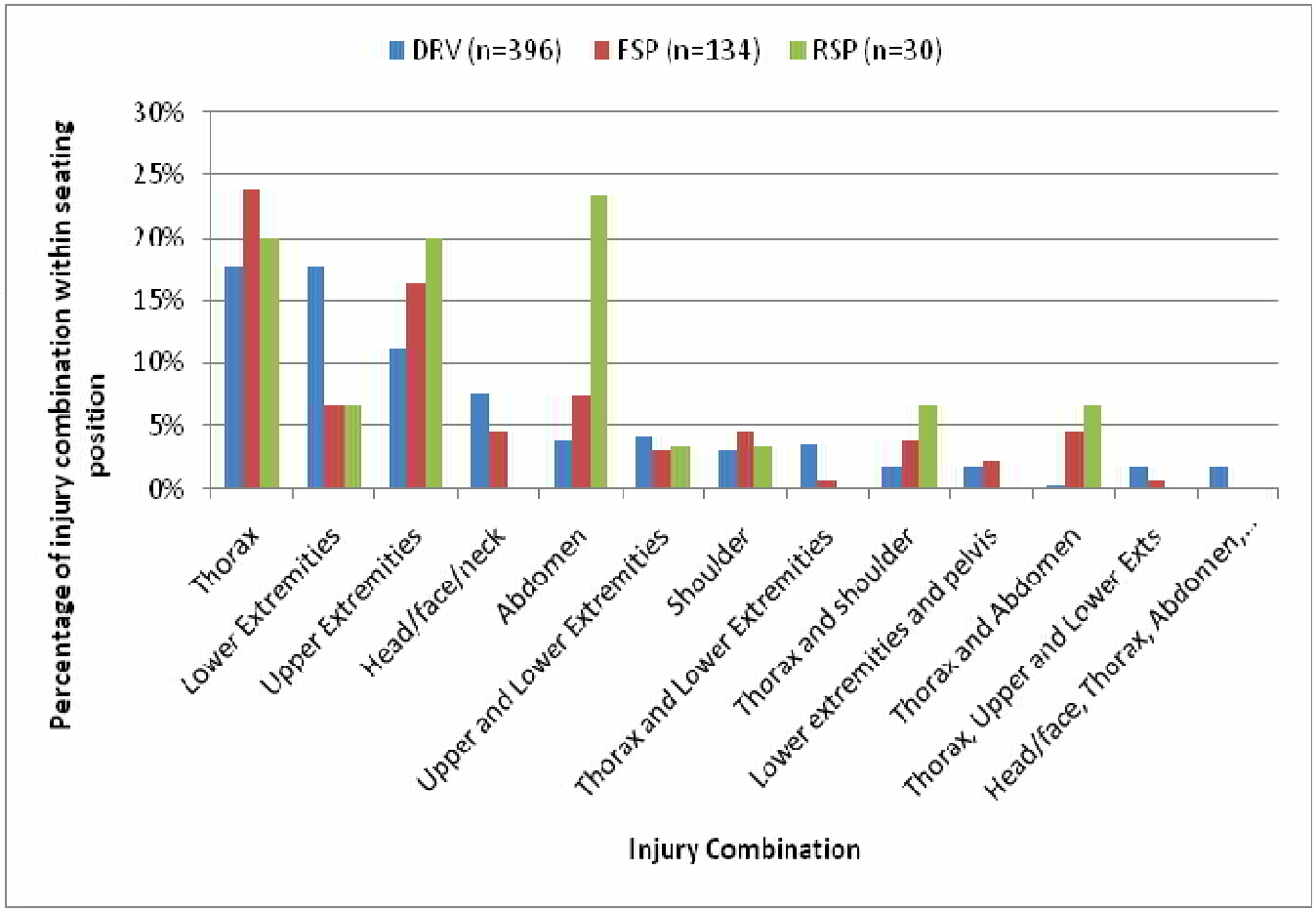
COVER Task 1.2 – Body Regions Injured

Body regions injured and MAIS injury level for all occupants in the frontal impact sample (CCIS sample)



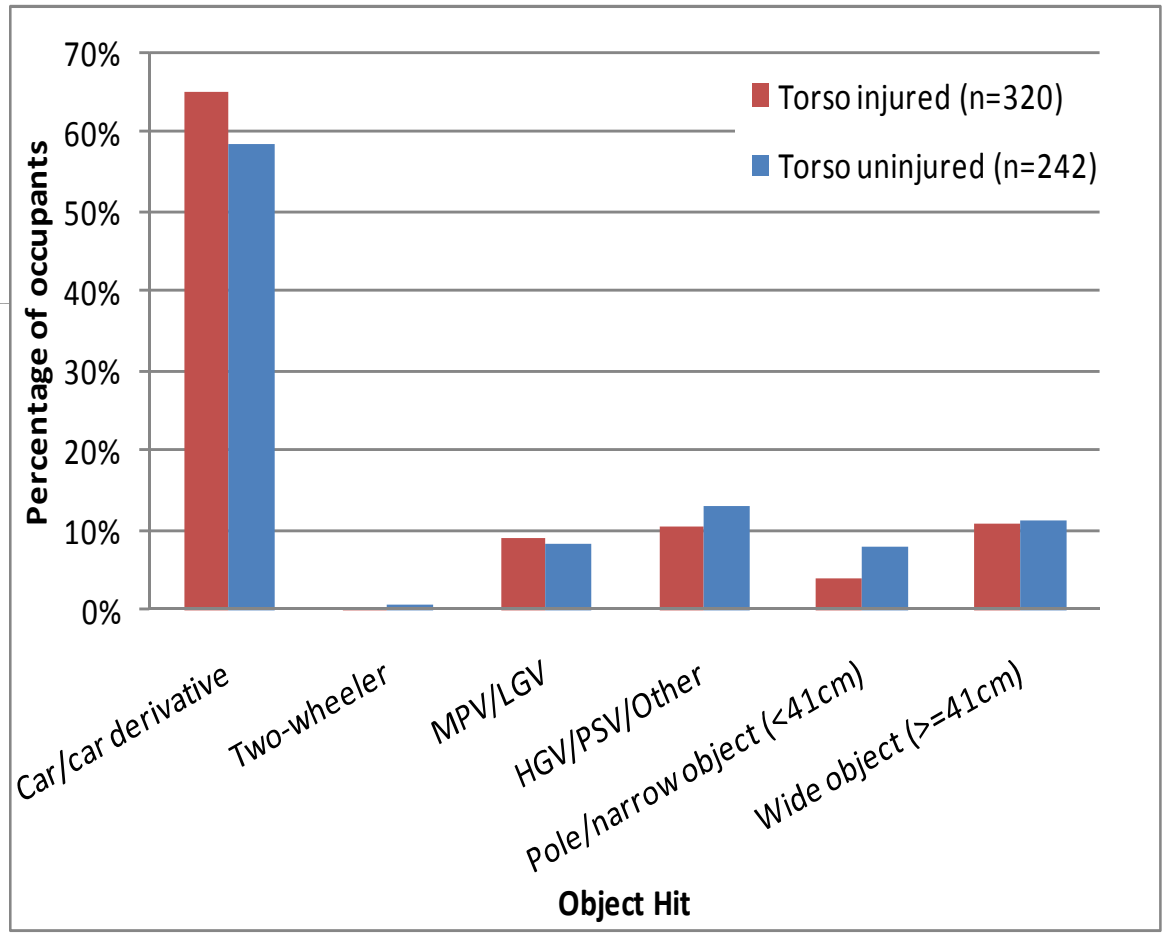
COVER Task 1.2 – Body Regions Injured

Injured (MAIS ≥ 2, including AIS 1 rib fractures) body region groupings for occupants in different seating positions (CCIS sample)



COVER Task 1.2 – Crash characteristics

Class of object hit in frontal collisions for KSI occupants with or without a torso injury (CCIS sample)

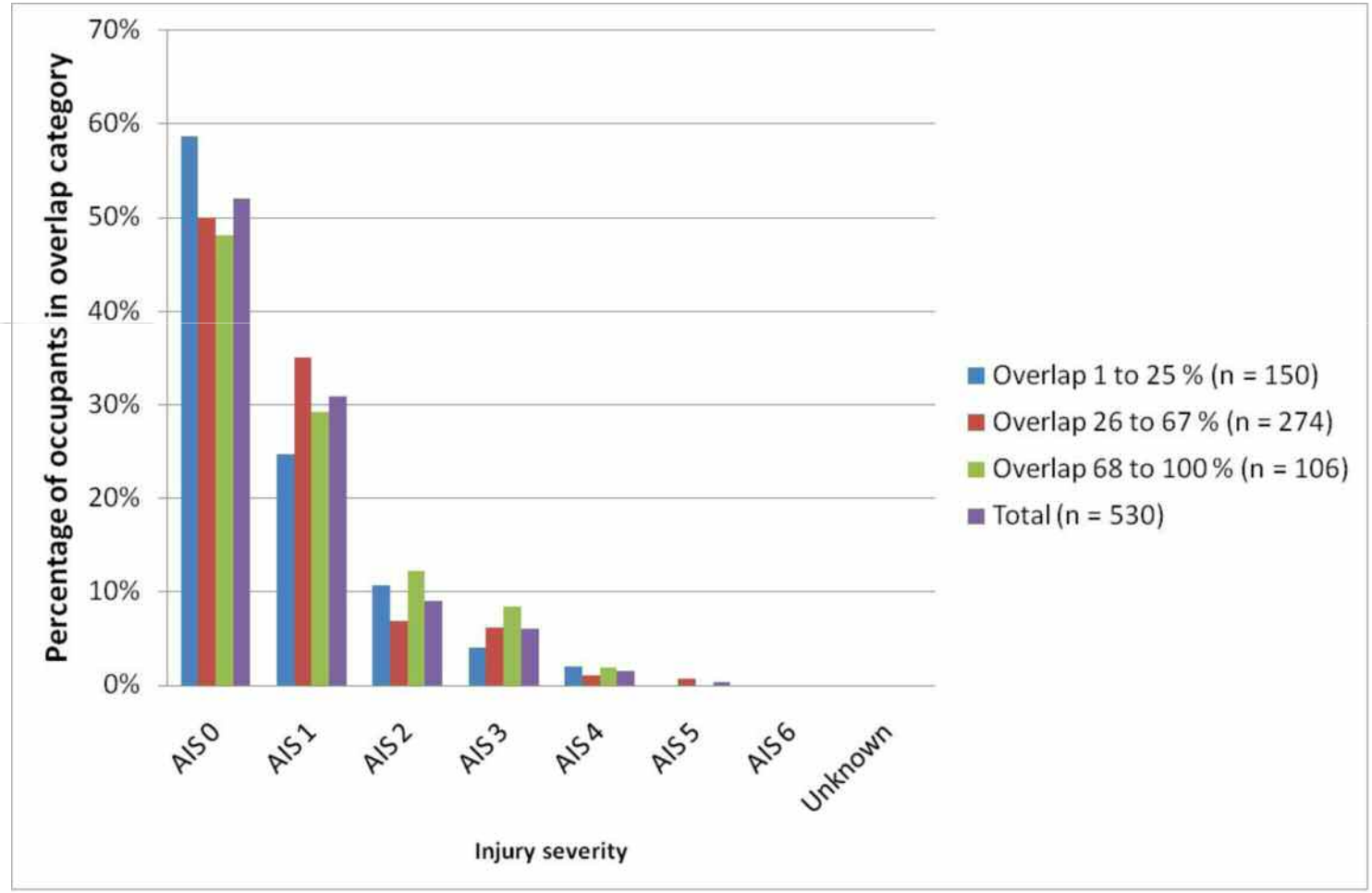


COVER Task 1.2 – Crash characteristics

The GIDAS analysis indicated that AIS ≥ 3 torso injuries were more likely to occur in impacts with narrow objects (those objects with a diameter less than 40 cm) than in collisions with other types of object

COVER Task 1.2 – Crash characteristics

Torso injury levels according to overlap categories (GIE RE PR sample)



COVER Task 1.2 – Crash characteristics

Front occupant according to EES categories

(N=530 occupants)

EES (kph)	Number of front occupants	Percentage (%)
<15	4	1
16-25	37	7
26-35	98	18
36-45	121	23
46-55	108	20
56-65	120	23
66-75	31	6
>75	11	2

With thoracic injuries (spleen or liver injuries), we have

- 90 AIS2+
- 42 AIS3+

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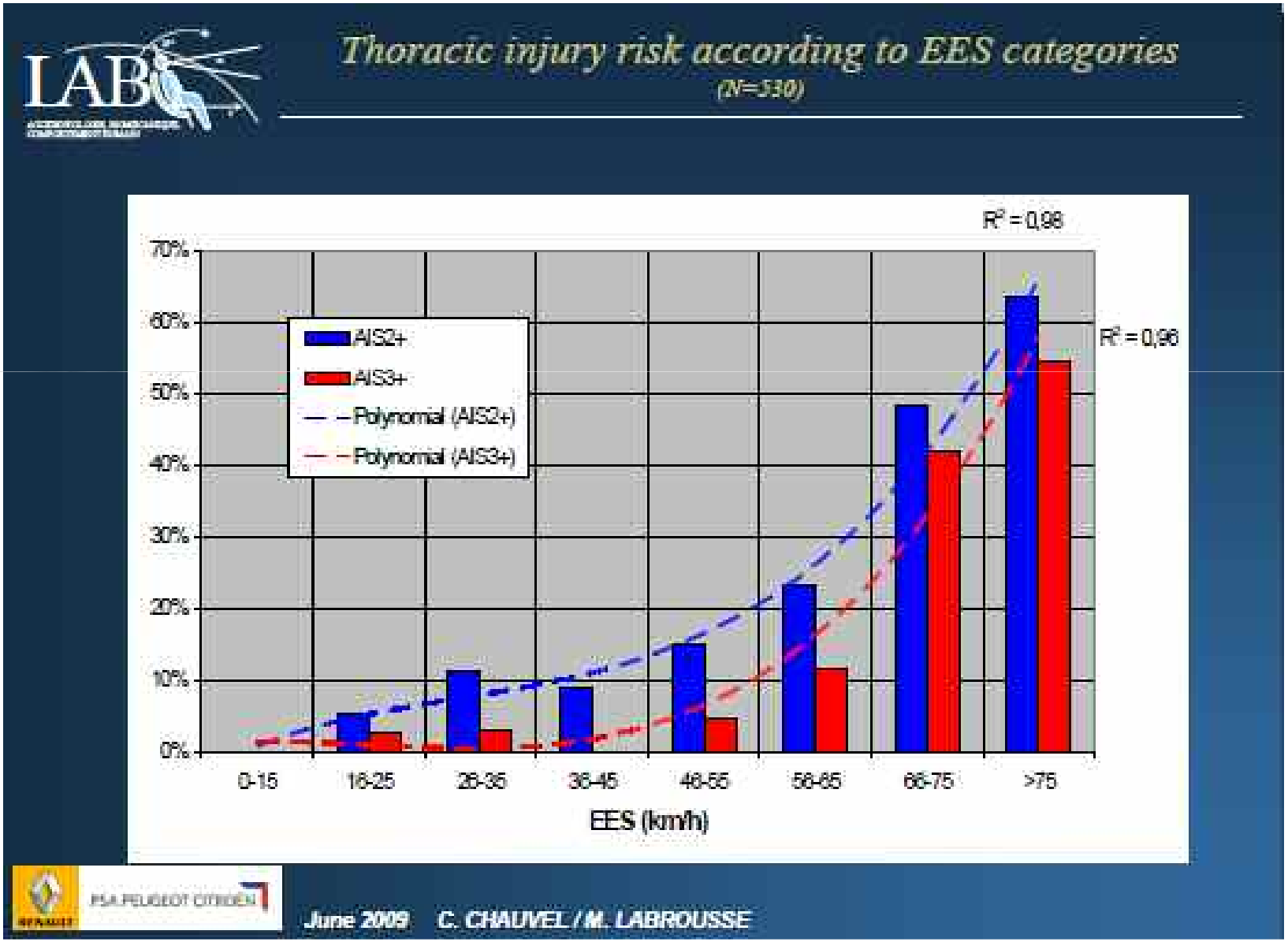
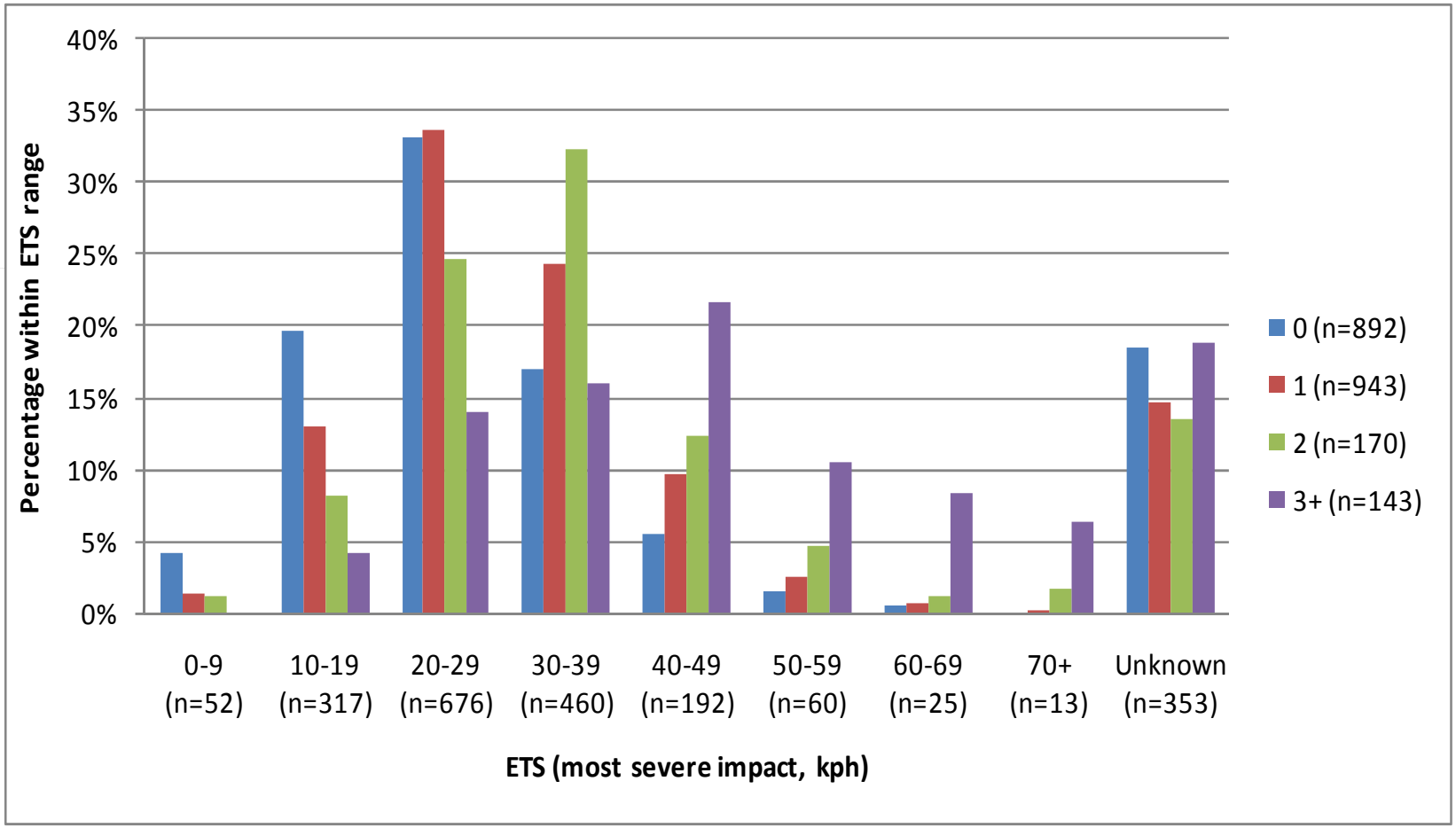
COVER Task 1.2 – Crash characteristics



COVER Task 1.2 – Crash characteristics

Distribution of torso injury by MAIS and Equivalent Test Speed (ETS) (CCIS sample)



COVER Task 1.2 – Crash characteristics

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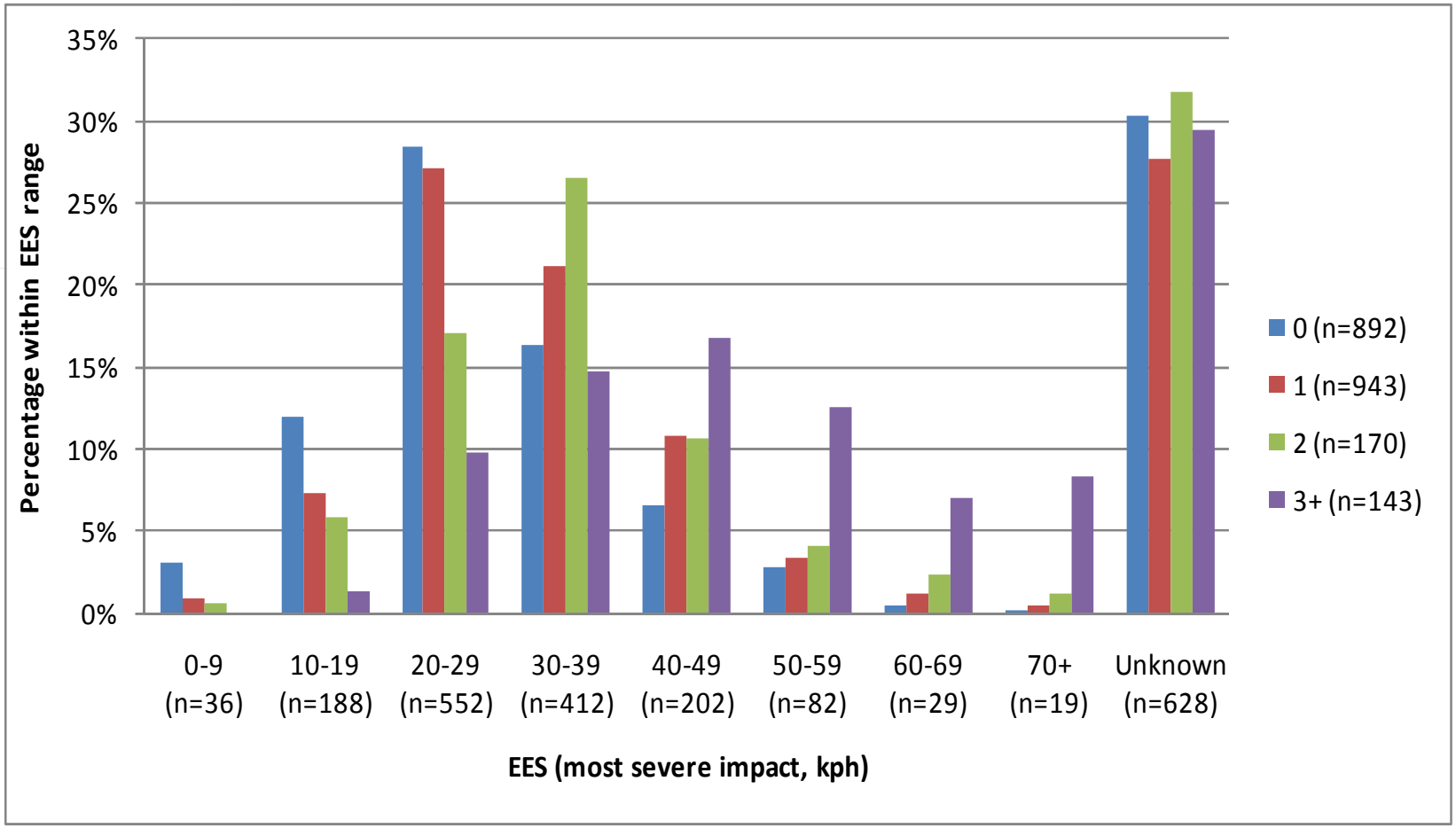


THORAX Task 1.1 – Crash characteristics

Content

Crash characteristics

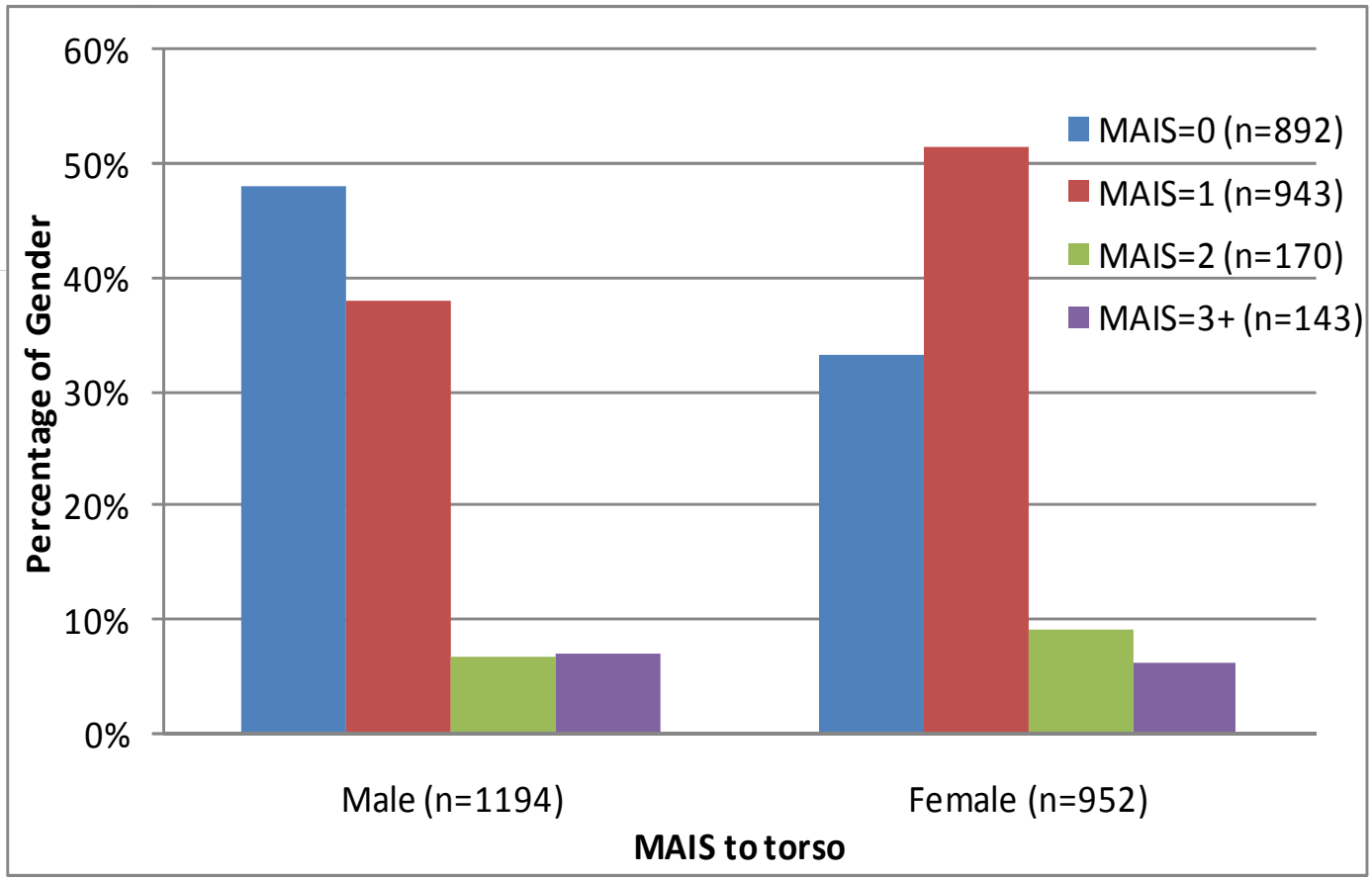
From detailed case review:

Cases chosen to be like Euro NCAP

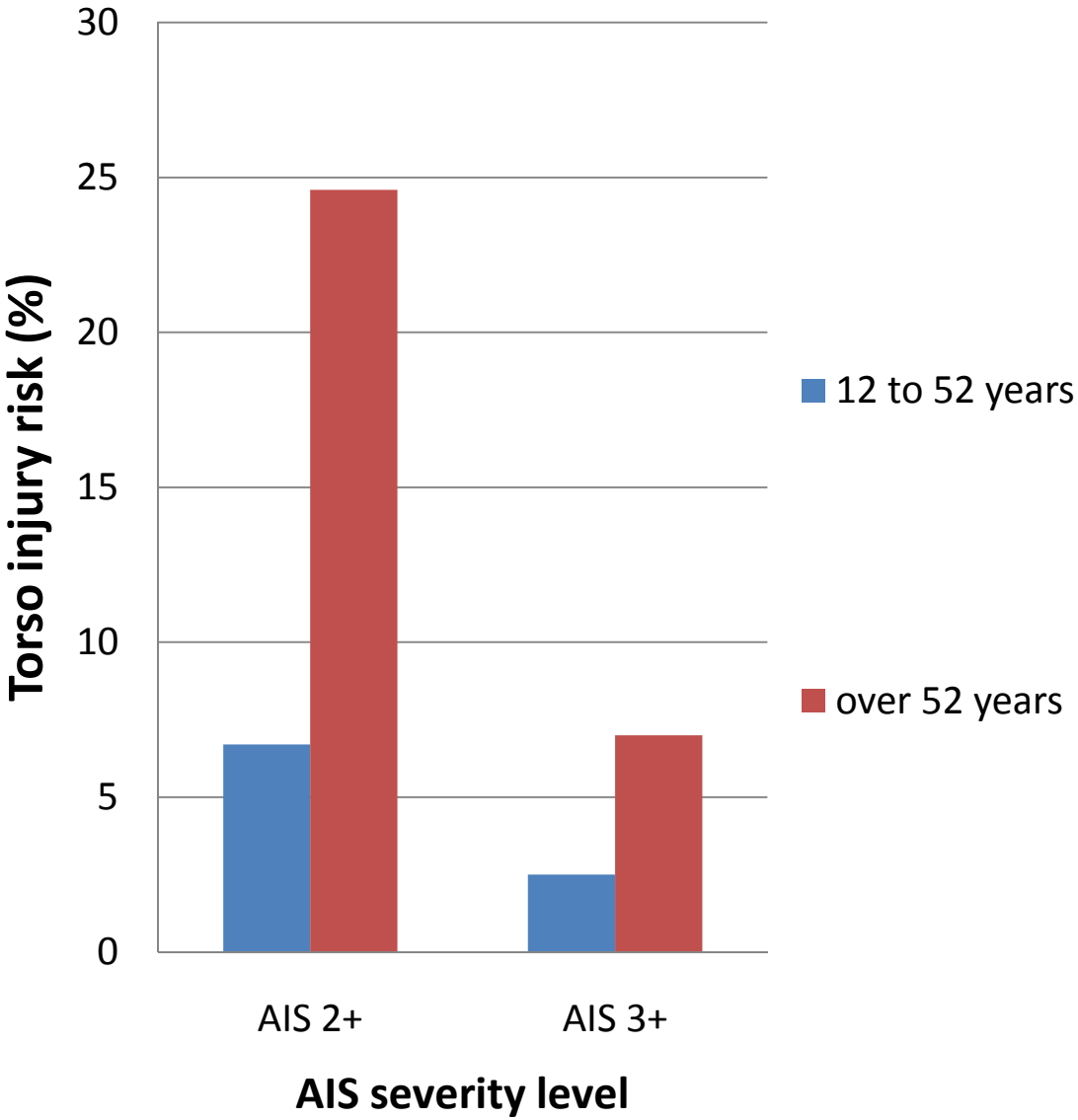
- Overlaps mostly comparable
- Deformation pattern of front structure and compartment similar to the deformation pattern in Euro NCAP
- Mostly lower delta-v than Euro NCAP
- Some cases >> intrusion at low Δv

COVER Task 1.2 – Occupant characteristics

Proportions of male or female occupants with each torso injury severity level (CCIS sample)



COVER Task 1.2 – Occupant characteristics

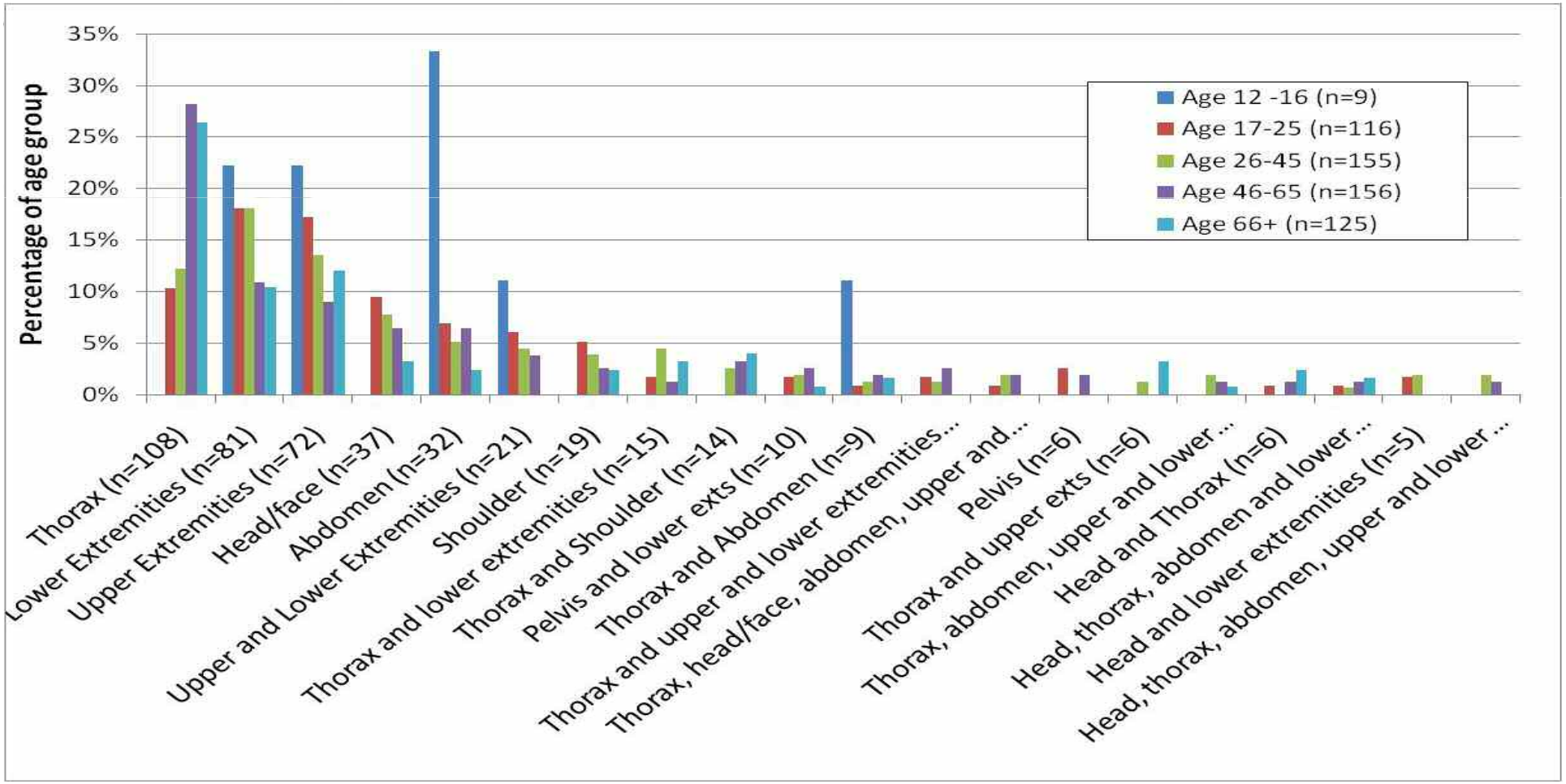


Torso injury risk, front belted occupants, frontal impact, from 12 to 52 years old (n = 339) (GIE RE PR sample)

Torso injury risk, front belted occupants, frontal impact, over 52 years old (n = 190) (GIE RE PR sample)

COVER Task 1.2 – Occupant characteristics

Combinations of AIS ≥ 2 injuries (including AIS 1 rib fractures) sustained by occupants as a proportion of the different age groups (CCIS sample)



COVER Task 1.2 – Occupant characteristics

- The GIDAS sample was able to show that:
  - Occupants who were 150 to 180 cm were more likely to have an AIS 1 torso injury than taller (180 to 220 cm) occupants
  - Occupants weighing 40 to 60 kg were statistically more likely to have an AIS 1 torso injury
- Neither of these trends were significant at the AIS 2 or ≥ 3 injury severity levels.

From detailed case review

- Front seat passengers suffered the more severe injuries, despite being on the non-struck side
- Front passengers were mostly women
  - lower injury tolerance level of females?
- Also?
  - Effectiveness of (aggressive) passenger airbag
  - Position of the front seat passenger immediately before the accident
  - Out of position

COVER Task 1.2 – Restraint systems

- The majority of front seat occupants in the sample of cars and car-derivatives, from 2000 onwards, had combined seat belt and airbag restraint
- 1758 occupants (82 percent) of the CCIS sample had a pre tensioning device fitted at their seating position
  - This proportion varied by seating position
- On the basis of the GIDAS sample, no significant effect could be proven based on the presence of seat belt pretensioners or load limiters
  - CCIS and GIDAS don't have specific info on the force limit used with each load limiter

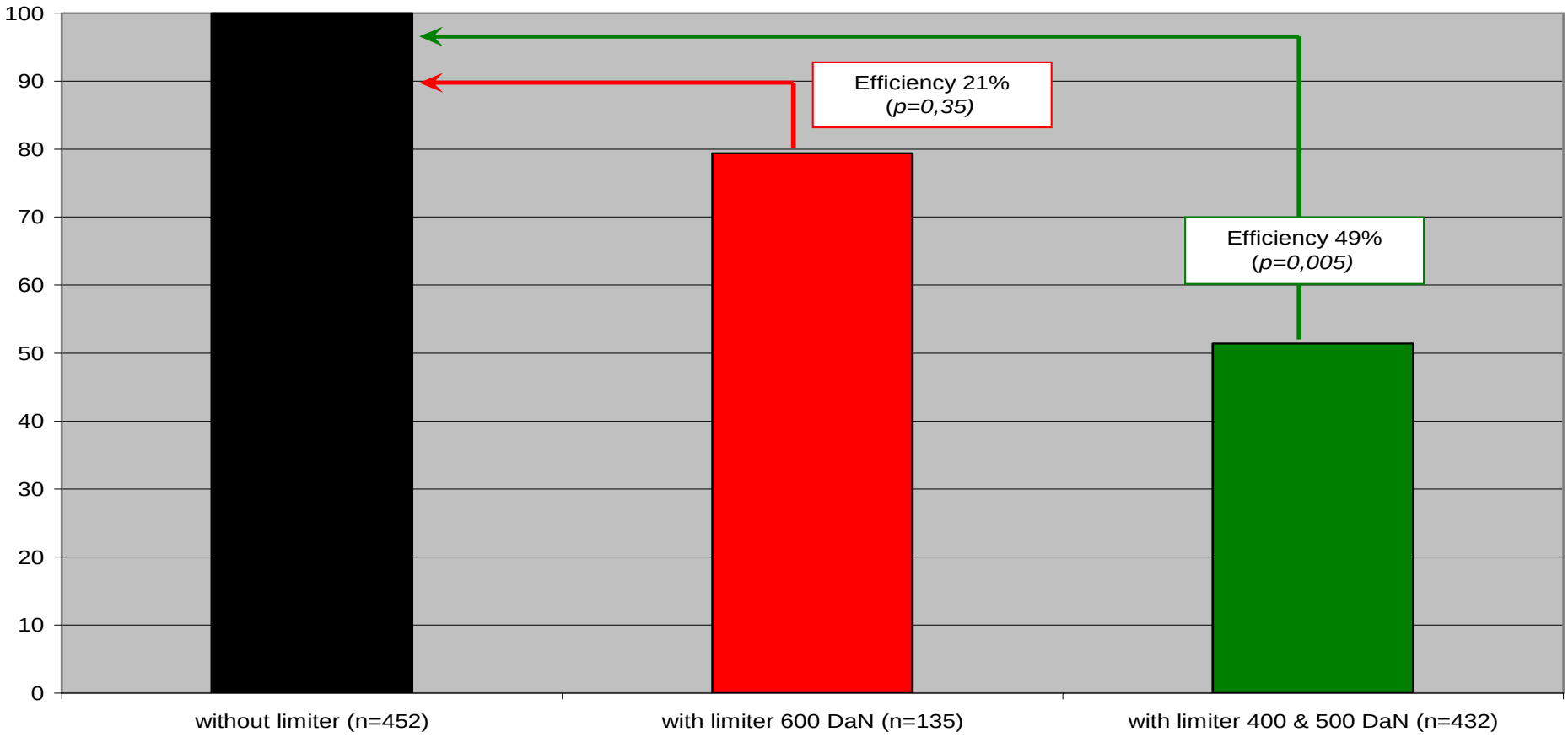
COVER Task 1.2 – Restraint systems

Load limiters:

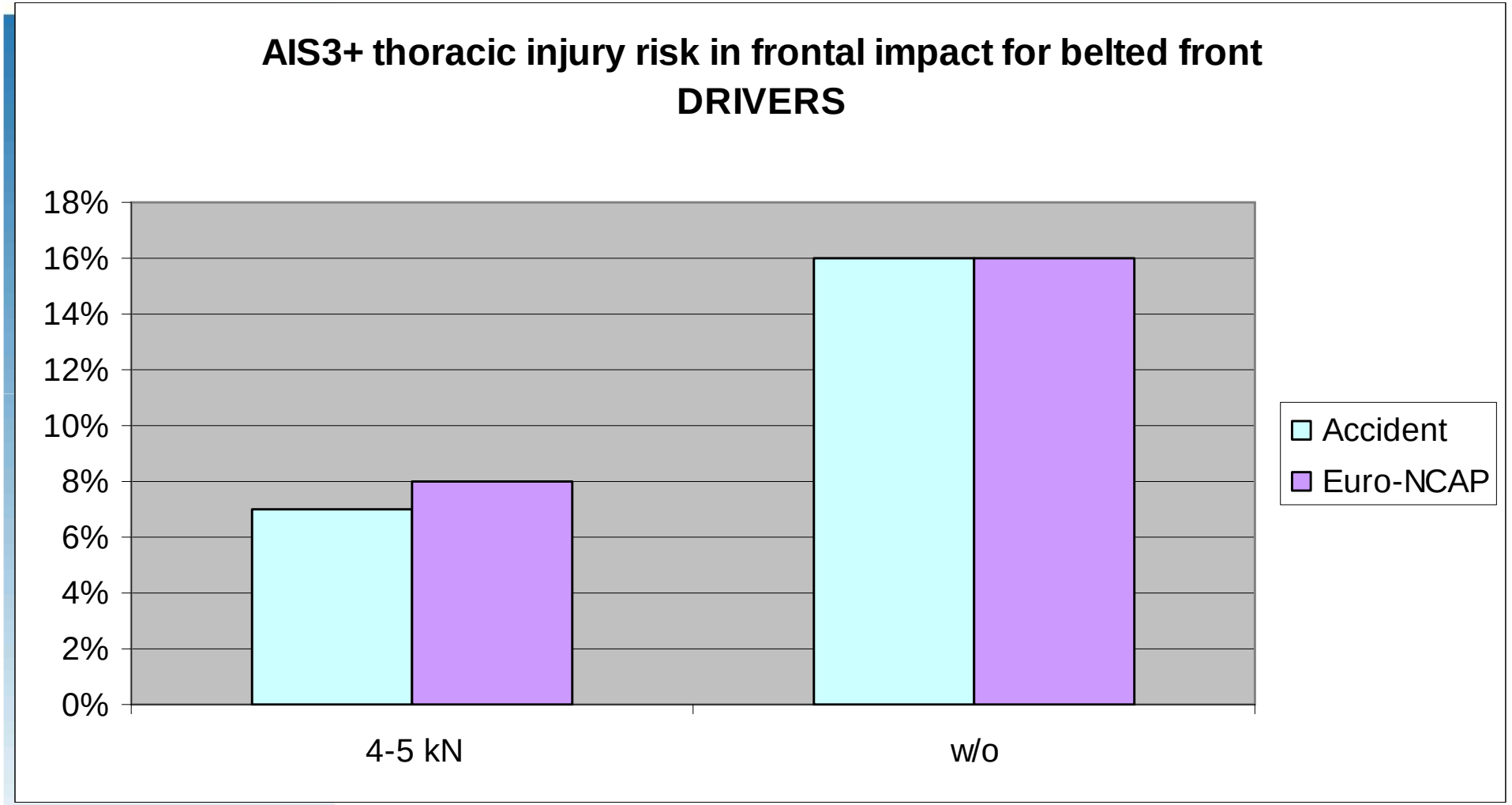
- Important to bear in mind that:
  - Women and younger car occupants were less likely to have a seat belt equipped with a load limiter
  - In the GIE RE PR sample cars with load limiters were likely to be involved in slightly more severe crashes

THORAX Task 1.1 – GIE RE PR analysis

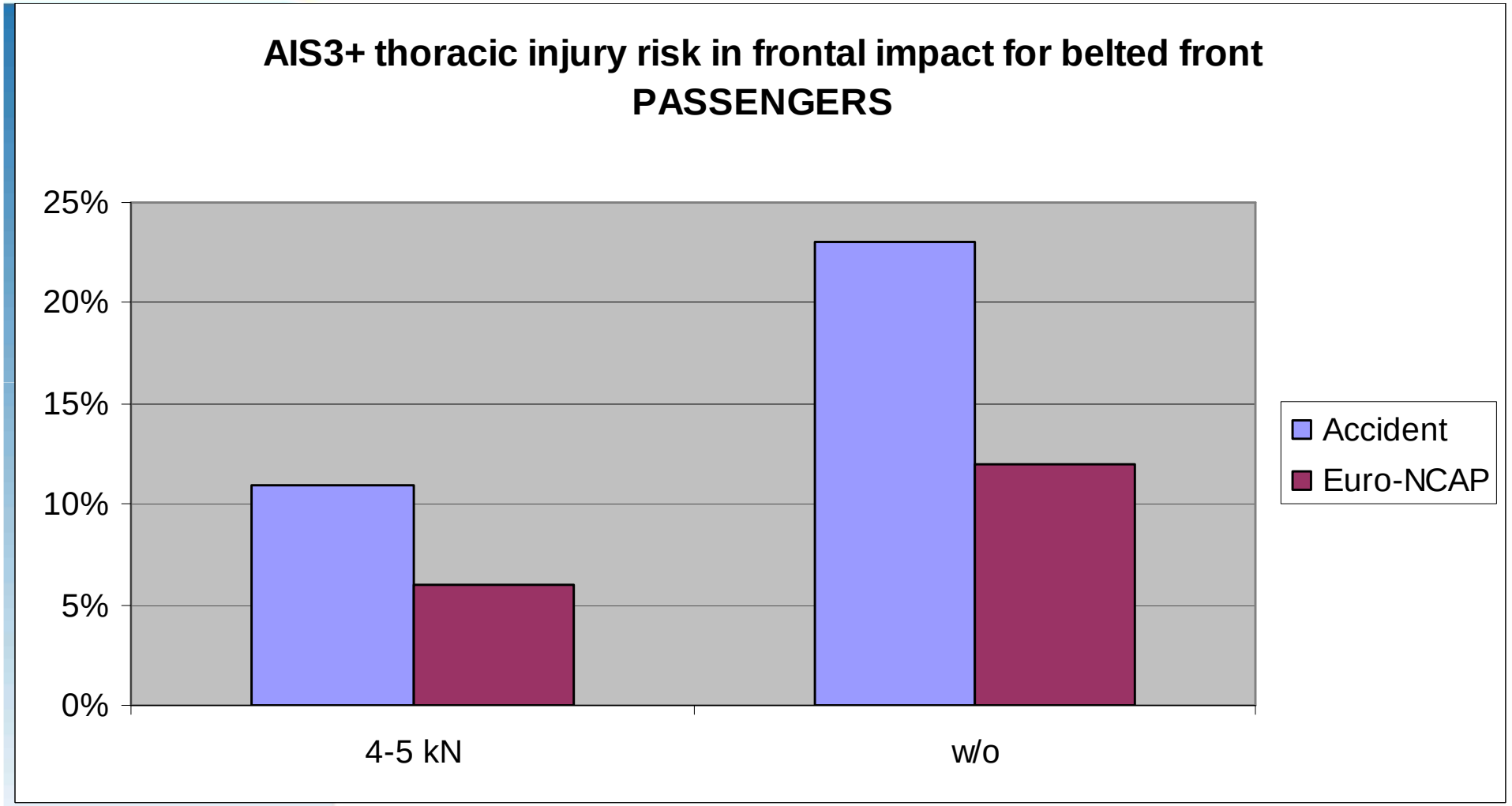
Réduction of the risks of AIS3+ thoracic injuries for the front passengers cars designed since 1990 in front impact for EES>45 km/h (With regard to a base of 100 passengers without load limiter)



THORAX Task 1.1 – GIE RE PR analysis

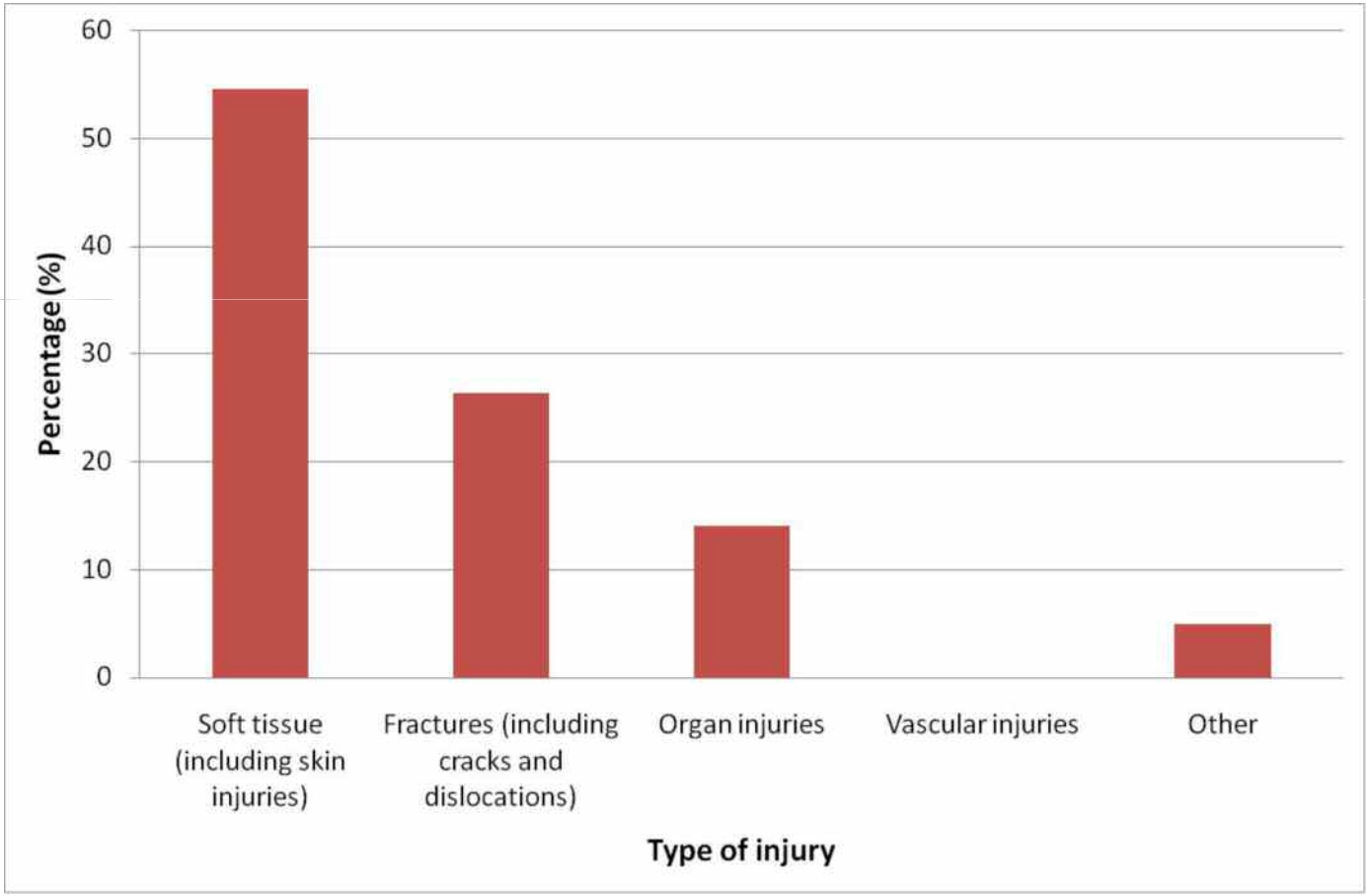


THORAX Task 1.1 – GIE RE PR analysis



COVER Task 1.2 – Specific injuries

Types of torso injury (GIE RE PR sample, n = 440)



COVER Task 1.2 – Specific injuries

Torso injuries sustained (AIS ≥ 2, including AIS 1 rib fractures) (CCIS sample)

	Torso body region								
	Upper abdomen	Lower abdomen	Other abdomen	Shoulder	Lung	Heart	Ribs	Sternum	Other thorax
Number of occupants	53	36	36	75	102	20	126	107	28
Percentage of all KSI (%)	9	6	6	13	18	4	22	19	5
Percentage of torso sample KSI (%)	17	11	11	23	32	6	39	33	9

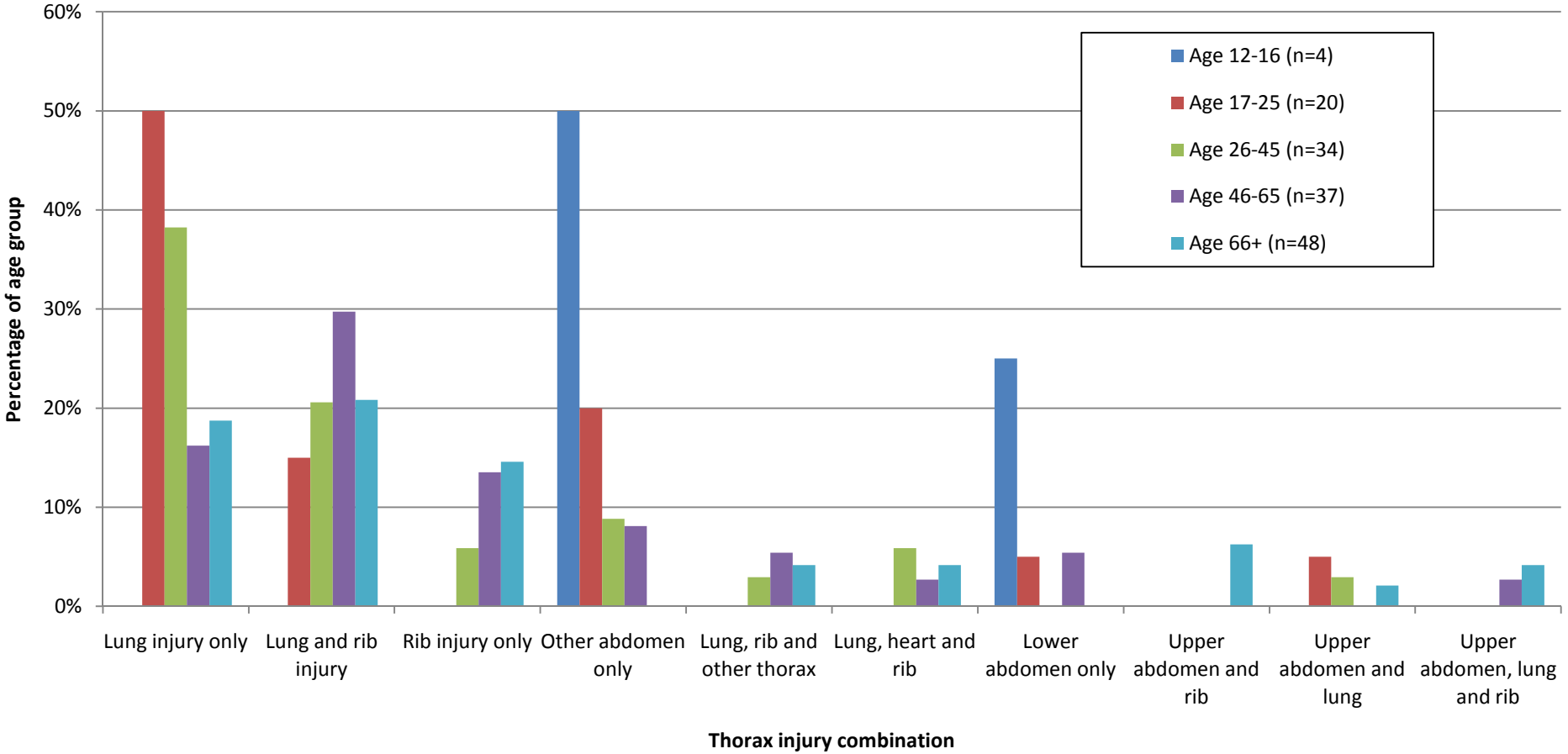
COVER Task 1.2 – Specific injuries

Internal organ injury distribution for the AIS ≥ 3 torso internal injury level (GIE RE PR sample)

Injured body part	Number	Percentage (%)
Lungs	21	41
Pleura	23	45
Mediastinum	3	6
Liver	3	6
Spleen	1	2
Total	**51**	**100**

COVER Task 1.2 – Specific injuries

Percentage distribution of torso injury combinations (AIS ≥ 3) occurring in the three different age groups (CCIS sample)



Similar effect of age seen in THORAX case-by-case

- Young occupants tended to receive no or only slight injuries even in quite severe accidents
- Elderly sustained moderate to severe injuries even without compartment intrusion

Conclusions

Thorax is most frequently injured single body region for front seat occupants, both for:

- MAIS ≥ 2 (when AIS 1 rib fractures are included as well)
- MAIS ≥ 3 severity levels (when the extremities are counted separately as left and right)

- Rear seat passengers receive more abdominal injuries than thorax injuries; although, the thorax remains the second most frequently injured body region

Conclusions

Content

Conclusions

Older occupants have more thoracic injuries (all severity levels)

- Implications for injury risk functions
- Statistically significant for the 65+

Females have more thoracic injuries

- Tend to be minor injuries (AIS 1)
- More injuries for occupants in the passenger seat (AIS 1 and 2)
  - More females in the passenger seat than males
- Trend not observed at AIS 3+

GIDAS data suggest that smaller and lighter occupants have more thoracic injuries (at AIS 1)

No statistically significant findings for other sizes

Conclusions

Content

Conclusions

Most crashes producing thoracic injuries (all severities) involve:

- Distributed loading to the vehicle front
- An ETS value of less than about 56 km/h

Injuries to the thorax can occur frequently at impact speeds below that of the current regulatory and consumer frontal impact test procedures

Most occupants who received an AIS ≥ 3 thorax injury were in a restraint system consisting of seat belt, airbag, pretensioner(s), and a load limiting device

- Pretensioner had no significant effect
- Load limiter seems to reduce AIS 3+ thorax injuries to AIS 2

Recommendations

Content

Recommendations

- Develop injury risk functions for female and elderly
- Consider whether dummy performance should be different for elderly

Recommendations

Testing:

- Additional tests at lower delta-v may be beneficial for encouraging good protection across a wider range of loading conditions
- Use female dummy in FSP position
  - Or at least use suitable risk functions
  - Investigate whether FSP restraints provide equivalent or lower protection c.f. driver restriants
- Consideration should also be given to testing with closer seat position for driver

Recommendations

Content

Recommendations

Dummy:

- Needs to be able to assess lung injury and rib fracture risk
- Additional benefit would be gained if dummy could be used at lower speeds
  - 40 to 49 km/h key speed range for serious (AIS 3+) injuries
- AIS 3+ lung injuries (with and without fracture) at conventional test speeds – and above
- Capability to detect differences in abdominal injury risk due to the restraint and seating environment