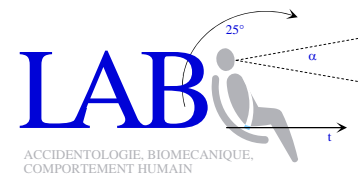


# Status of the WorldSID injury risk curves

on behalf of ISO/WG6

March, 2012



# Outline

- Conclusion of the work included in the TR12350 and in Stapp 2009
- Definition of guidelines to build injury risk curves
- Selection of injury risk curves
  - ✓ Based on Akaike (AIC) criterion
  - ✓ Based on the quality index
  - ✓ Based on engineering judgment
- WorldSID 50th injury risk curves

# Conclusion of the work included in the TR12350 and in Stapp 2009

- Injury risk curves constructed:
  - ✓ Based on selected PMHS samples
  - ✓ For commonly used measurements
  - ✓ With commonly used statistical methods
  - ✓ Without correction for age and for 45-year-old
- TR12350 updated with a new methodology and the injury risk curves dedicated to the WorldSID 50<sup>th</sup> percentile
- Publication at Stapp 2009 providing the injury risk curve adjusted to 45-year-old

# Injury risk curves as proposed in Stapp 2009

## *Shoulder*

## *Thorax*

## *Abdomen*

## *Pelvis*

Shoulder injury risk AIS2+ as a function of shoulder force

Shoulder injury risk AIS2+ as a function of shoulder deflection

Thoracic skeletal injury risk AIS3+ as a function of rib deflection

Thoracic skeletal injury risk AIS4+ as a function of rib deflection

Thoracic skeletal injury risk AIS3+ as a function of rib VC

Thoracic skeletal injury risk AIS4+ as a function of rib VC

Abdomen injury risk AIS2+ as a function of abdomen rib deflection

Abdomen injury risk AIS3+ as a function of abdomen rib deflection

Abdomen injury risk AIS2+ as a function of abdomen rib VC

Abdomen injury risk AIS3+ as a function of abdomen rib VC

Abdomen injury risk AIS2+ as a function of lower spine acceleration

Abdomen injury risk AIS3+ as a function of lower spine acceleration

Pelvis injury risk AIS2+ as a function of pubic force

Pelvis injury risk AIS3+ as a function of pubic force

Pelvis injury risk AIS2+ as a function of pelvis acceleration

Pelvis injury risk AIS3+ as a function of pelvis acceleration

# Definition of guidelines to build injury risk curves

- ISO/WG6 agreed on guidelines to build injury risk curves
- These guidelines include several steps
- Among those:
  - ✓ The use of the survival analysis
  - ✓ The release of the injury risk curves associated to a quality index based on the width of the confidence intervals
  - ✓ The recommendation of an injury risk curve per body region, injury type and injury level

# Selection of injury risk curves

- Based on the Akaike (AIC) criterion
  - ✓ Based on maximum likelihood but weighted by the number of variables
  - ✓ Only possible comparing two injury risk curves built with identical samples

# Selection of the injury risk curves

*Shoulder*

*Thorax*

*Abdomen*

*Pelvis*

Shoulder injury risk AIS2+ as a function of shoulder force

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~~Thoracic skeletal injury risk AIS3+ as a function of rib VC~~

~~Thoracic skeletal injury risk AIS4+ as a function of rib VC~~

Abdomen injury risk AIS2+ as a function of abdomen rib deflection

Abdomen injury risk AIS3+ as a function of abdomen rib deflection

Abdomen injury risk AIS2+ as a function of abdomen rib VC

Abdomen injury risk AIS3+ as a function of abdomen rib VC

~~Abdomen injury risk AIS2+ as a function of lower spine acceleration~~

~~Abdomen injury risk AIS3+ as a function of lower spine acceleration~~

Pelvis injury risk AIS2+ as a function of pubic force

Pelvis injury risk AIS3+ as a function of pubic force

Pelvis injury risk AIS2+ as a function of pelvis acceleration

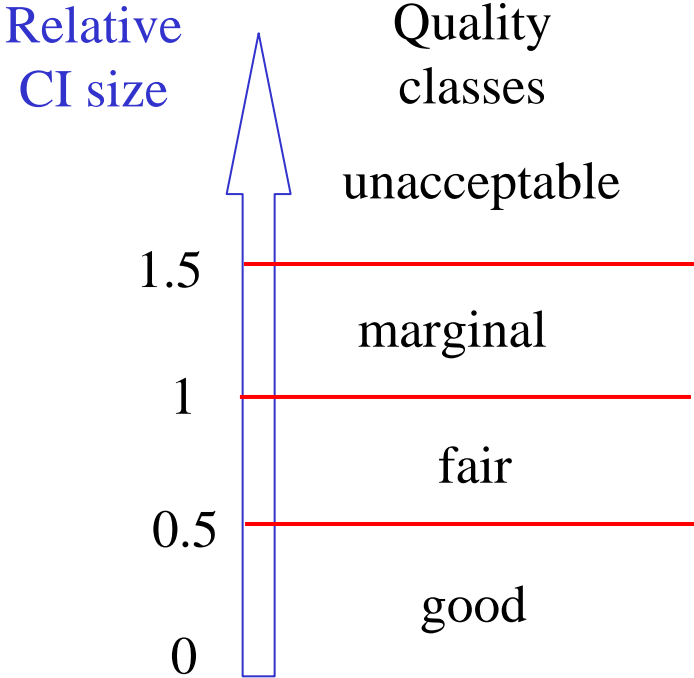
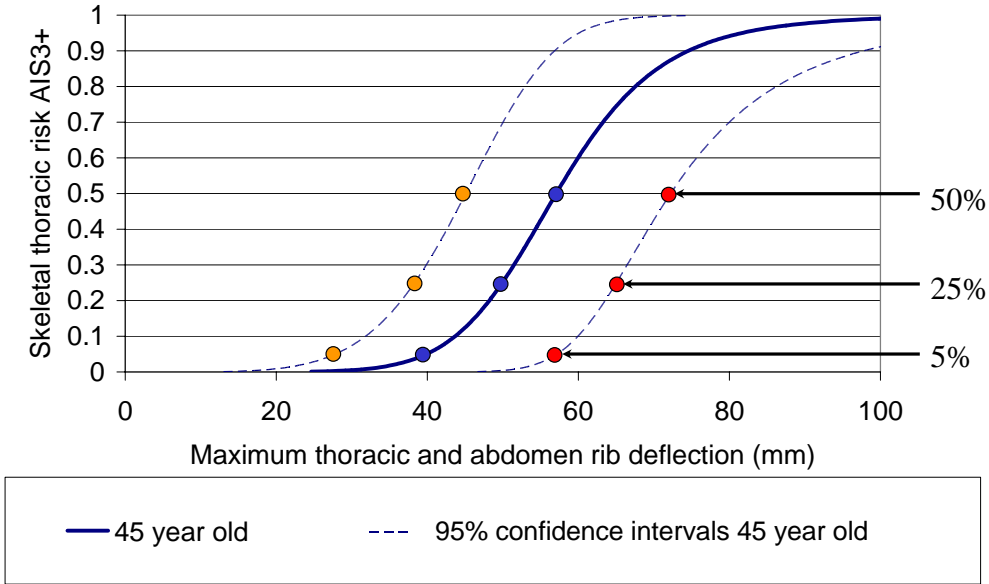
Pelvis injury risk AIS3+ as a function of pelvis acceleration

Based on AIC



# Selection of injury risk curves

- Based on the quality index
  - Based on width of the confidence intervals
  - Curves with unacceptable quality classes are not recommended



Relative CI size =  $\frac{\text{upper bound of the CI} - \text{lower bound of the CI}}{\text{value of dummy measurement at this risk}}$





# Selection of the injury risk curves

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*Thorax*

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*Pelvis*

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~~Abdomen injury risk AIS3+ as a function of lower spine acceleration~~

Pelvis injury risk AIS2+ as a function of pubic force

Pelvis injury risk AIS3+ as a function of pubic force

Pelvis injury risk AIS2+ as a function of pelvis acceleration

~~Pelvis injury risk AIS3+ as a function of pelvis acceleration~~

Based on AIC

Based on quality classes



# Selection of injury risk curves

- Based on engineering judgment
  - ✓ SHOULDER: The test sample used for the construction of the IRC as a function of the shoulder deflection includes only impactor tests, while the sample for the construction of the IRC as a function of the shoulder force includes both impactor and sled tests
    - Recommendation of the IRC as a function of the shoulder force
  - ✓ ABDOMEN: The quality index is better for the curve as a function of the abdomen rib deflection than for the one as a function of the abdomen rib VC
    - Recommendation of the IRC as a function of the maximum abdomen rib deflection
  - ✓ PELVIS: Most of the injuries observed in the PMHS tests used to build the injury risk curves are related to ilio-ischio rami and pubic symphysis
    - Recommendation of the dummy measurement which is the more closely related to these injuries: pubic force

# Selection of the injury risk curves

## *Shoulder*

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Pelvis injury risk AIS2+ as a function of pubic force

Pelvis injury risk AIS3+ as a function of pubic force

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~~Pelvis injury risk AIS3+ as a function of pelvis acceleration~~

Based on AIC

Based on quality classes

Based on engineering judgment



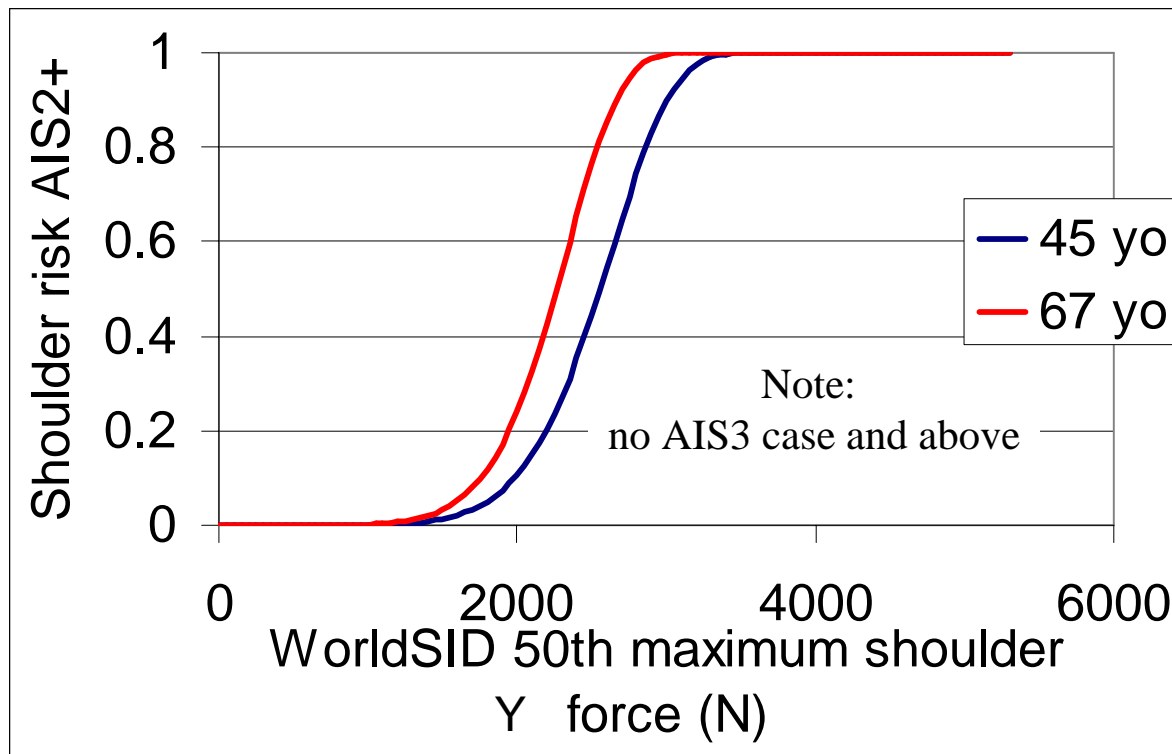
## WorldSID 50th injury risk curves

- at 45 yo (target age of the occupant to protect)
- and at the median age of the PMHS used to build the curve (age closer to those of the PMHS → more information available → confidence in the curves is more important)

# WorldSID 50th injury risk curves

## ➤ Shoulder injury risk AIS2+

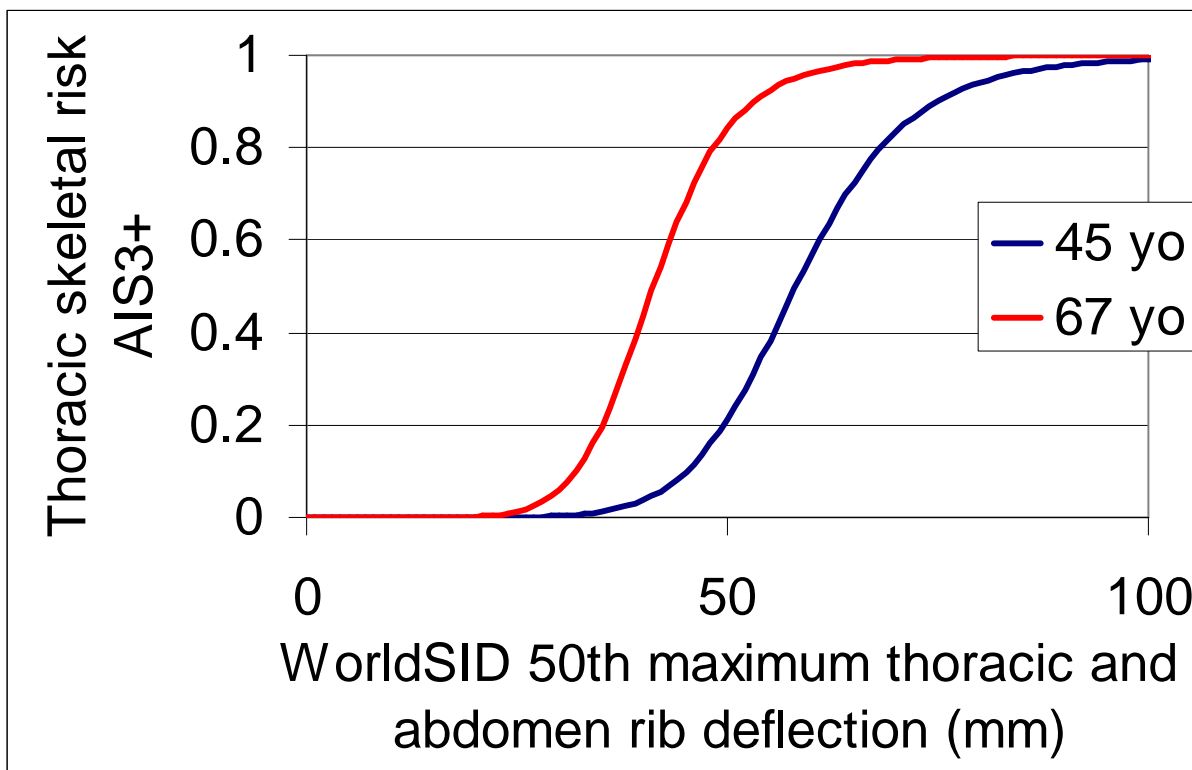
Maximum shoulder Y force (N)	5% AIS2+	quality index at 5% AIS2+	25% AIS2+	quality index at 25% AIS2+	50% AIS2+	quality index at 50% AIS2+
45 year old	1799	fair	2270	fair	2556	fair
67 year old	1594	good	2011	good	2265	good



# WorldSID 50th injury risk curves

## ➤ Thoracic skeletal injury risk AIS3+

Maximum thorax and abdomen rib deflection (mm)*	5% AIS3+	quality index at 5% AIS3+	25% AIS3+	quality index at 25% AIS3+	50% AIS3+	quality index at 50% AIS3+
45 year old	41.4	fair	51.2	fair	58.1	good
67 year old	29.3	fair	36.3	good	41.2	good

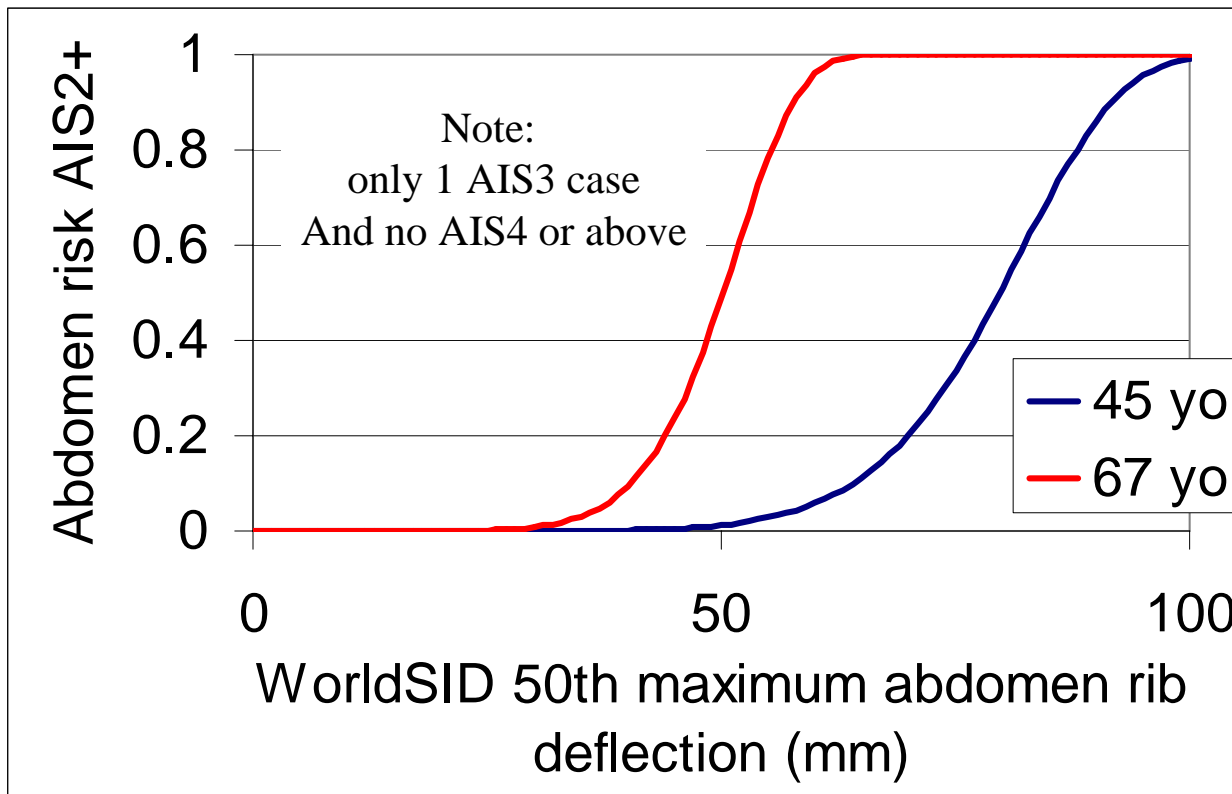


\* Measured by  
1D IR-TRACC

# WorldSID 50th injury risk curves

## ➤ Abdomen injury risk AIS2+

Maximum abdomen rib deflection (mm) *	5% AIS2+	quality index at 5% AIS2+	25% AIS2+	quality index at 25% AIS2+	50% AIS2+	quality index at 50% AIS2+
45 year old	58.9	fair	72.0	fair	79.8	fair
67 year old	37.1	fair	45.3	good	50.2	good



\* Measured by  
1D IR-TRACC

# WorldSID 50th injury risk curves

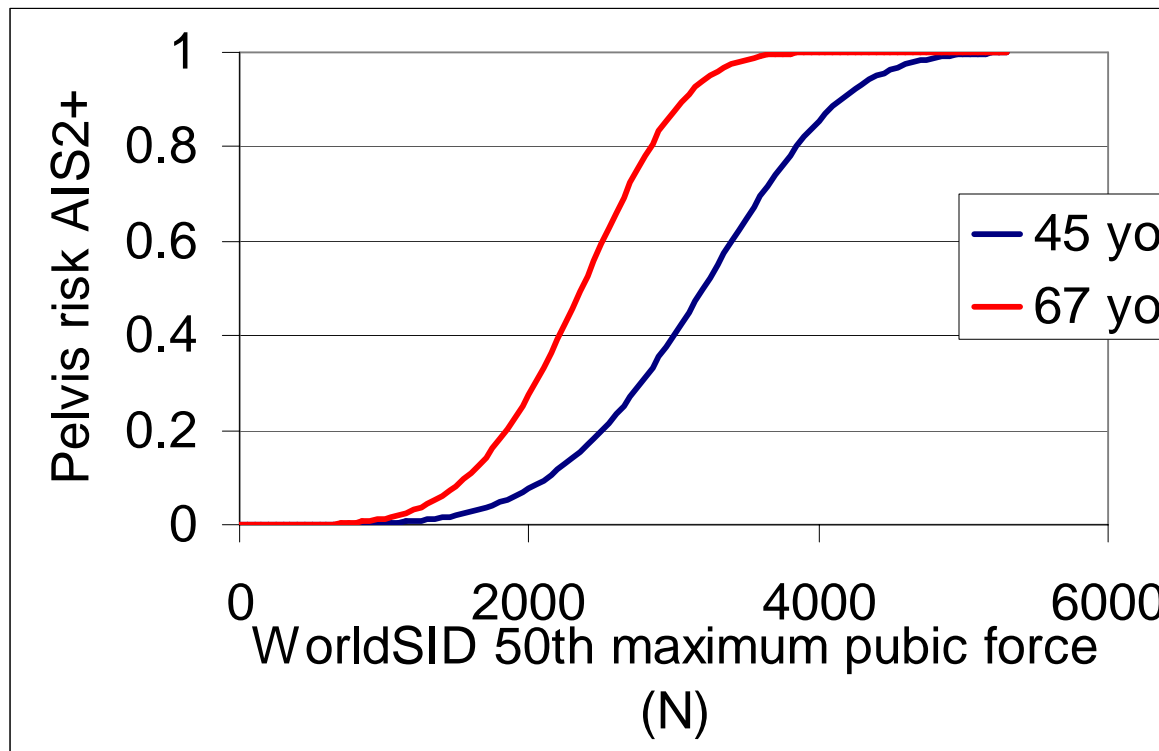
- Skeletal thoracic injury risk is determined as a function of the maximum of the thoracic and abdomen rib deflection
- Abdomen injury risk is determined as a function of the maximum abdomen rib deflection
- Given the injury thresholds presented in the two previous slides, if the skeletal injury risk is below a given level, the abdomen risk will also be below this level of risk



# WorldSID 50th injury risk curves

## ➤ Pelvis injury risk AIS2+

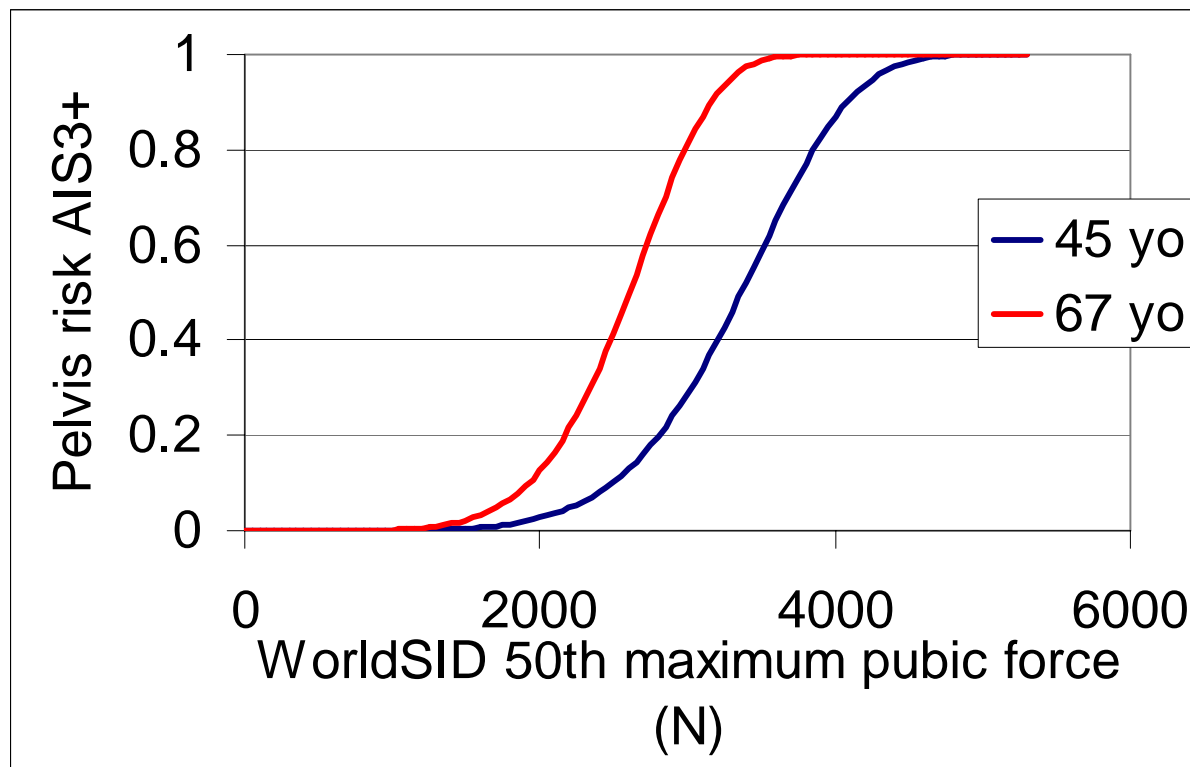
Maximum pubic force (N)	5% AIS2+	quality index at 5% AIS2+	25% AIS2+	quality index at 25% AIS2+	50% AIS2+	quality index at 50% AIS2+
45 year old	1818	fair	2645	marginal	3202	marginal
67 year old	1340	fair	1950	good	2361	good



# WorldSID 50th injury risk curves

## ➤ Pelvis injury risk AIS3+

Maximum pubic force (N)	5% AIS3+	quality index at 5% AIS3+	25% AIS3+	quality index at 5% AIS3+	50% AIS3+	quality index at 5% AIS3+
45 year old	2214	marginal	2922	marginal	3365	marginal
67 year old	1714	good	2262	good	2605	good



## WorldSID 50th injury risk curves

- Agreement within ISO/WG6
- TR12350 to be updated early 2012
  - ✓ Vote by the ISO/SC12 by the end of 2012