

# AUTOMOBILE SAFETY CONSIDERATIONS DURING PREGNANCY

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**CHALMERS**  
UNIVERSITY OF TECHNOLOGY



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INDUSTRITEKNIK

**Autoliv**

**Folksam**

# UVA Center for Applied Biomechanics

- ▶ UVA Dept. of Mechanical and Aerospace Engineering
- ▶ 30+ years in injury biomechanics: automobile safety, sports, defense – experimental, modeling, epidemiology
  - Diverse group of 50+ people in a 30,000 ft<sup>2</sup> facility
    - 7 faculty (4 School of Engineering, 3 School of Medicine)
    - 10 research scientists (PhD)
    - 12 technicians and engineers
    - 20+ graduate students, interns



# Automobile Safety During Pregnancy

## ► Unique challenges:

- Protection of both the mother and the fetus
- Safety perceptions
- Anthropometry
- Belt use & fit
- Unique injury types

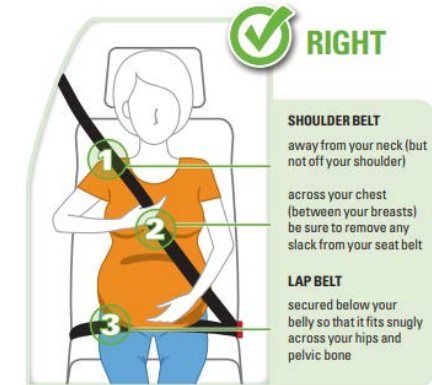


TABLE 2

## Estimated incidence/prevalence of injury by type of trauma during pregnancy

Mechanism of injury	Estimated incidence/prevalence in pregnancy	Study design	Estimated incidence/prevalence outside of pregnancy
Motor vehicle crashes	207/100,000 live births <sup>11</sup>	Population-based cohort	1104/100,000 women <sup>c99</sup>
Falls and slips	48.9/100,000 live births <sup>24</sup>	Retrospective case-control	3029/100,000 women <sup>100</sup>
Burns	0.17/100,000 person-years <sup>27</sup>	Retrospective case-control	2.6/100,000 person-years <sup>27</sup>
Accidental poisoning	N/A	N/A	N/A
Domestic violence	8307/100,000 live births <sup>101</sup>	Review	5239/100,000 women <sup>c44</sup>
Suicide <sup>a</sup>	2/100,000 live births <sup>61</sup>	Retrospective cohort	8.8/100,000 population <sup>c102</sup>
Homicide	2.9/100,000 live births <sup>61</sup>	Retrospective cohort	2.3/100,000 women <sup>100</sup>
Penetrating trauma <sup>b</sup>	3.27/100,000 live births <sup>c62</sup>	N/A	3.4/100,000 women <sup>c62</sup>
Toxic exposure	25.8/100,000 person-years <sup>103</sup>	Retrospective cohort	115.3/100,000 person-years <sup>104</sup>

Literature relating to incidence of burns during pregnancy is limited to most severe cases admitted to burn units and referral centers. Rate for accidental poisoning during pregnancy could not be calculated from available published literature. Domestic violence incidence includes all forms of partner violence: sexual, physical, and psychological. N/A, not available.

<sup>a</sup> Rates exclude attempted suicides. Attempted suicide rate during pregnancy is approximately 40/100,000 pregnancies<sup>65</sup> and during postpartum period is 43.9/100,000 live births<sup>66</sup>; <sup>b</sup> Rates include only causes leading to fatality; <sup>c</sup> Rates calculated using 2009 US data from Centers for Disease Control and Prevention.

Mendez-Figueroa. Trauma in pregnancy. Am J Obstet Gynecol 2013.

MOTOR VEHICLE COLLISIONS (MVC) ARE LEADING CAUSE OF UNINTENTIONAL INJURY FOR PREGNANT WOMEN (U.S.)

# PREGNANT MVC INJURY ESTIMATES IN U.S.

2.96 mil

Pregnant individuals in US at any given time

84-215 k

Pregnant automobile occs. in *all crashes*

27-66 k

Pregnant automobile occs. in *injury crashes*

*Estimates from CDC birth data (2020-2021) and NHTSA female age 16-45 driver and collision data (2019-2020).*

# PREGNANT MVC INJURY ESTIMATES IN U.S.

290-770

Maternal deaths

550-1,420

Perinatal deaths

1.4-3.5 k

Placental abruptions

*Estimates from CDC birth data (2020-2021), NHTSA female age 16-45 driver and collision data (2019-2020), and Amezcua-Prieto et al. 2020 estimates (specific to pregnant MVCs).*

## COMPARISONS TO OTHER POPULATIONS (U.S.)

Statistic	Pregnant automobile occupants	Children (<=14)	All other
Population	2.96 mil	60.3 mil	263 mil
All crashes	84-215 k		9.1 mil
Injury crashes	27-66 k	139 k	2.8 mil
Fatalities	290-770 (maternal) 550-1,420 (perinatal)	1,093	41,000

# SAFETY CONSIDERATIONS FOR PREGNANT OCCUPANTS



How does a pregnant occupant interact with the vehicle environment (especially seat belts)?



What injuries patterns are observed in the pregnant population?



What tools exist and are needed to further assess PO safety?



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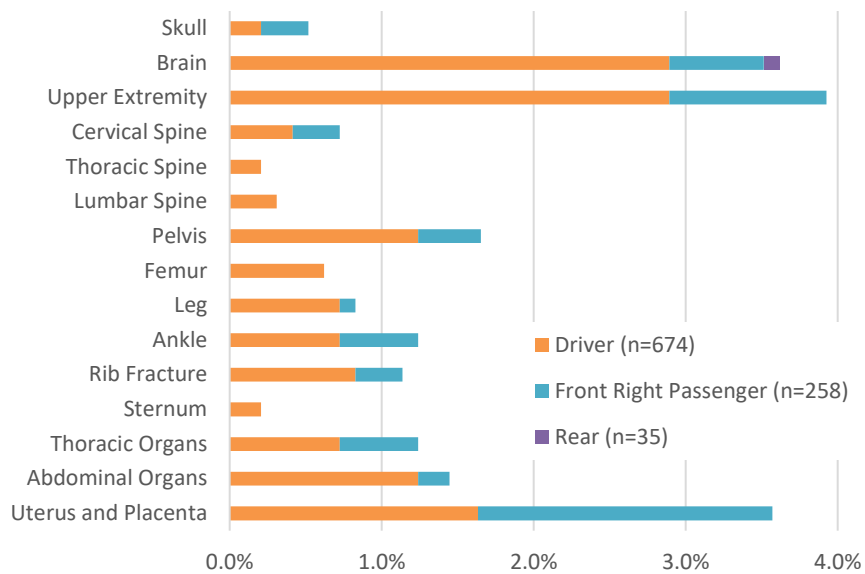


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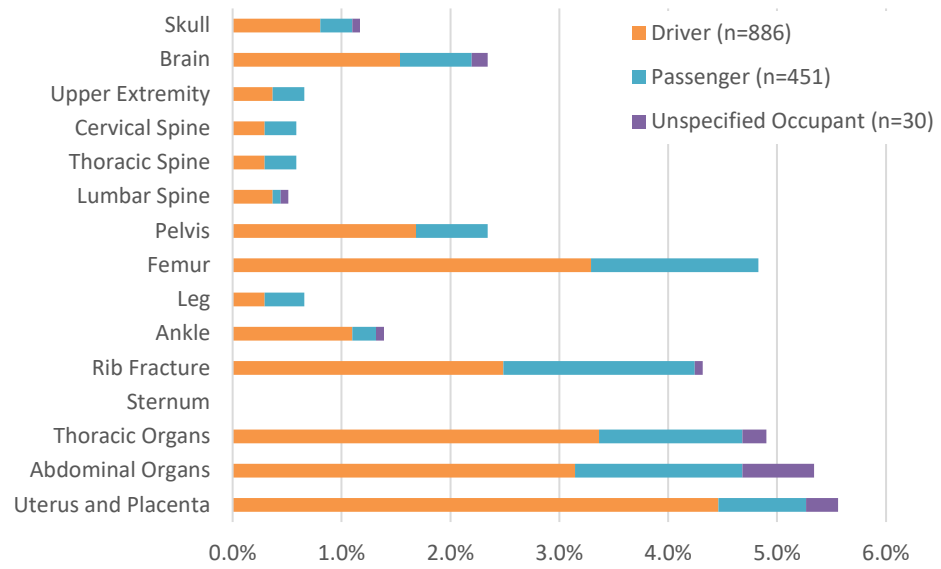
(# cases with injury to that region) / (total # cases)

# INJURY TYPES – PREGNANT AUTOMOBILE OCCS.

UNWEIGHTED NASS-CDS and CISS 1998-2021  
**Belted AIS 2+**

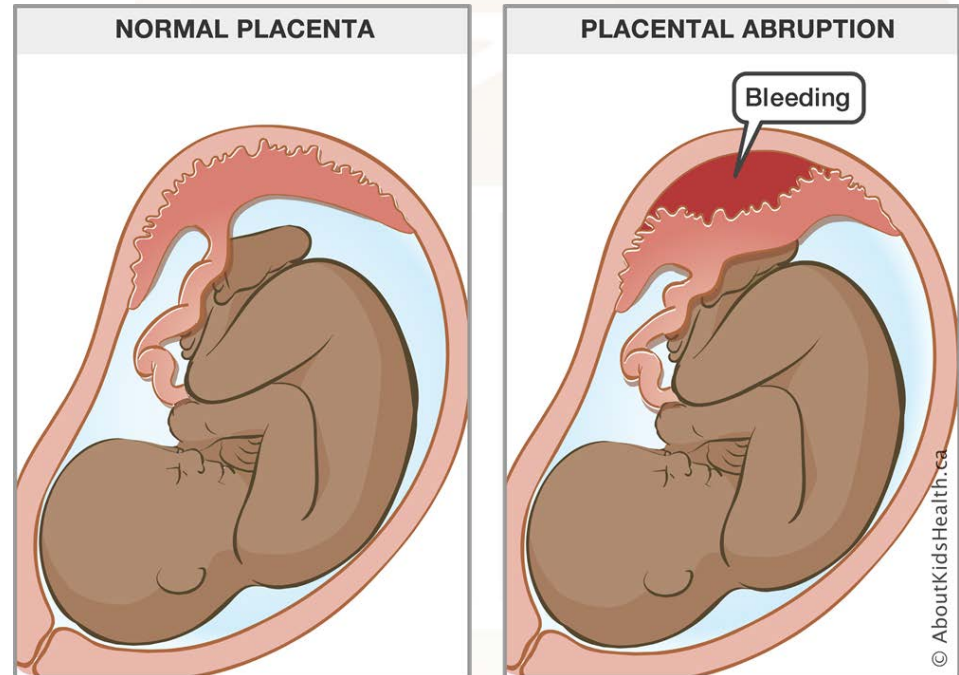


National Trauma Data Bank 2020-2021  
**Belted AIS 3+**



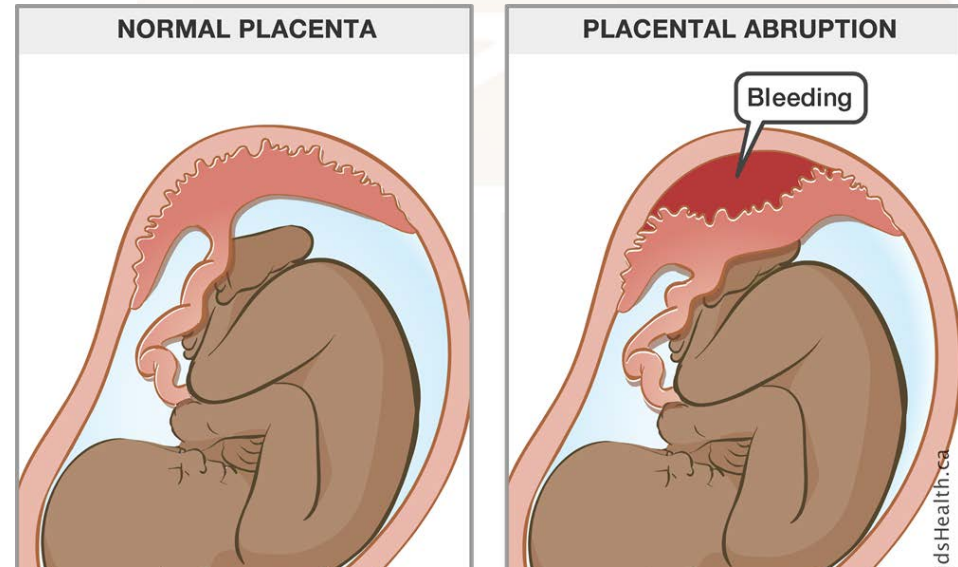
# Placental Abruption

- ▶ Placenta: provides the diffusion interface between the fetal and maternal circulatory systems to exchange oxygen & nutrients
- ▶ High blood flow near an interface that's “designed” to detach
- ▶ “Abruptio” = early separation of the placenta from the uterus
- ▶ High risk of fetal death (also a potential cause of maternal fatality)



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- All pregnant women involved in crashes, even minor ones, should immediately seek medical attention. In most cases with fetal loss, the mother sustained only minor or no other injuries other than placental, uterine, or fetal damage.

Klinich et al. 1998

# SAFETY CONSIDERATIONS FOR PREGNANT OCCUPANTS



How does a pregnant occupant interact with the vehicle environment (especially seat belts)?



Hesitancy?  
Belt Fit?

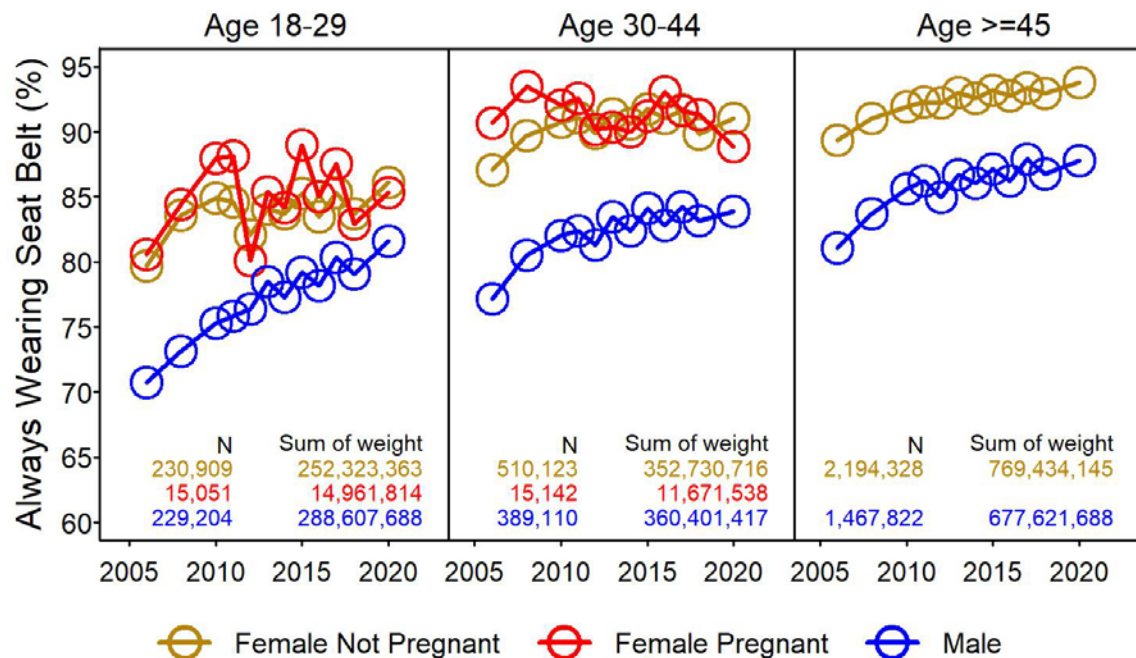
# Belt Use Rates for Pregnant Women

Recent UVA analysis using Behavioral Risk Factor Surveillance Systems (BRFSS)

- Pregnant women report wearing their belts at similar rates to their age group



Challenge: many pregnant women in younger age group, where belt use is lower



Published: JAMA Network Open 2024 (Espelien et al.)

# NHTSA GUIDANCE ON SEAT BELT USE

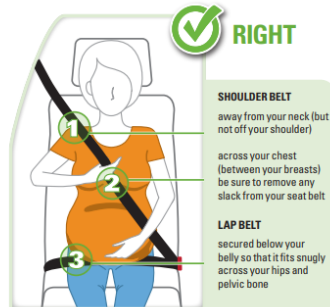
## IF YOU'RE **PREGNANT** SEAT BELT RECOMMENDATIONS FOR DRIVERS AND PASSENGERS

### I'M PREGNANT. SHOULD I WEAR A SEAT BELT?

**YES**—doctors recommend it. Buckling up through all stages of your pregnancy is the **single most effective** action you can take to protect yourself and your unborn child in a crash.

**NEVER**  
drive or ride in a car  
without **buckling up** first!

### WHAT'S THE RIGHT WAY TO WEAR MY SEAT BELT?



### SHOULD I ADJUST MY SEAT?



\* If you need additional room, consider adjusting the steering wheel or having someone else drive, if possible.

\*\* If you're a passenger, move your seat back as far as possible.

# American College of Obstetricians and Gynecologists

## Why is it important to wear a seat belt when I travel during pregnancy?

“Although your fetus is protected inside your body, you should wear a lap and shoulder belt every time you travel while you are pregnant for the best protection—even in the final weeks of pregnancy. You and your fetus are much more likely to survive a car crash if you are buckled in.”

## How should I wear a seat belt while I am pregnant?

- Buckle the lap belt below your belly so that it fits snugly across your hips and pelvic bone.
- Place the shoulder belt across your chest (between your breasts) and over the mid-portion of your collar bone (away from your neck).
- Never place the shoulder belt under your arm or behind your back.
- Pull any slack (looseness) out of the belt.
- If you are in an accident, seek medical attention right away, even if you are not injured.



# Pregnancy Risk Assessment Monitoring Survey (PRAMS)

During a prenatal visit with a clinician, the following percentage of post-partum women recalled counseling regarding...

**Drinking alcohol**

72%

**Smoking cigarettes**

71%

**Using seat belt**

???

Submitted to the Society of Maternal Fetal Medicine, 2024 (Gallagher et al.)

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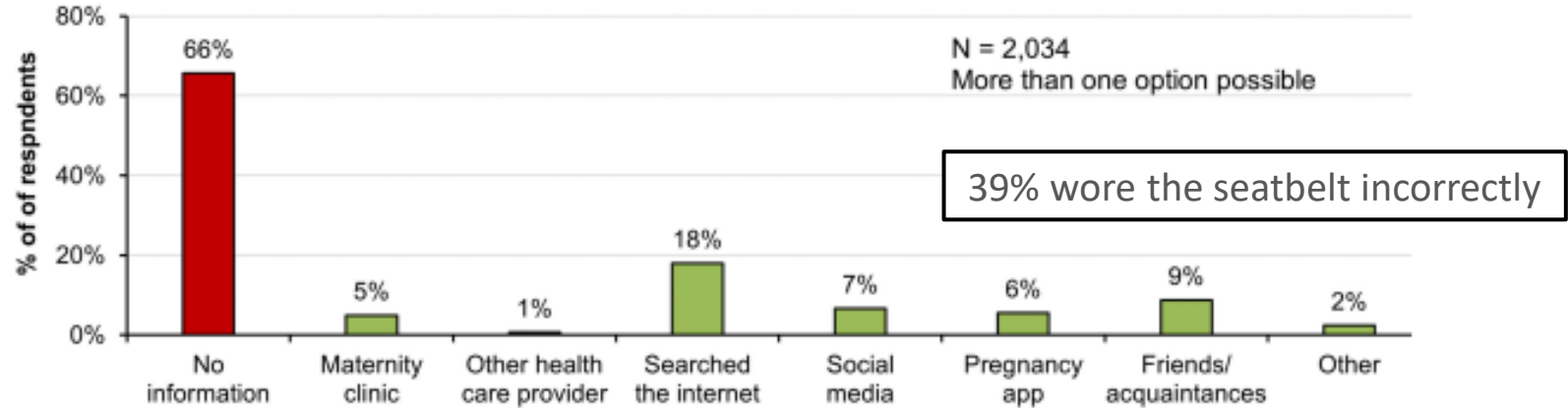
71%

**Using seat belt**

54%

Submitted to the Society of Maternal Fetal Medicine, 2024 (Gallagher et al.)

# SEAT BELT USE GUIDANCE FOR PREGNANT WOMEN



*Figure 2. Responses to the question 'From whom did you receive the information of how to wear the seatbelt during pregnancy?' (N = 2,034; more than one option possible).*

# Belt Use & Fit

- ▶ Belt use, fit, and perceptions for pregnant women
- ▶ Design and mobility barriers to good belt fit



Klinich et al. 1998



Comfortable Position



Rear-adjusted Position

Ongoing research at:  
 University of Virginia  
 Monash University  
 The George Institute  
 University of British Columbia



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### WHAT'S THE RIGHT WAY TO WEAR MY SEAT BELT?



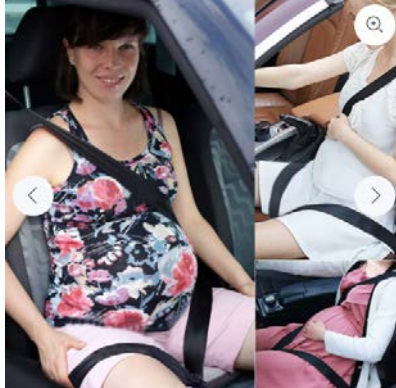
### SHOULD I ADJUST MY SEAT?



National  
 Highway Traffic  
 Safety  
 Administration

# Comfort Products

- Re-direct belt away from abdomen



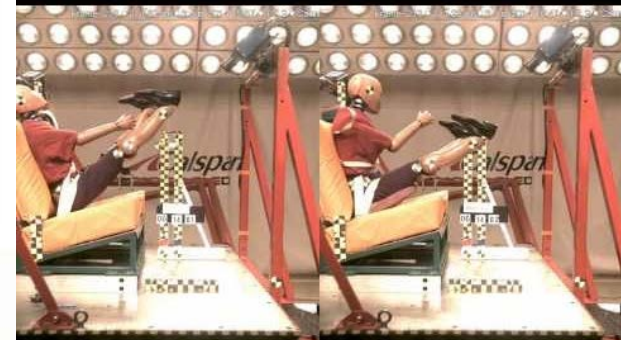
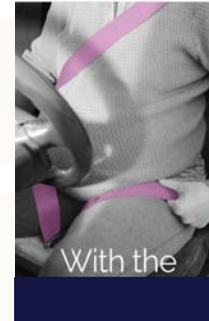
8 lbs. of  
high tensile  
stainless steel



comfortable  
foam cushion



crash tested





# Comfort Products

- ▶ Re-direct belt away from abdomen

8 lbs. of  
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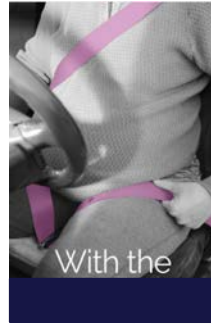
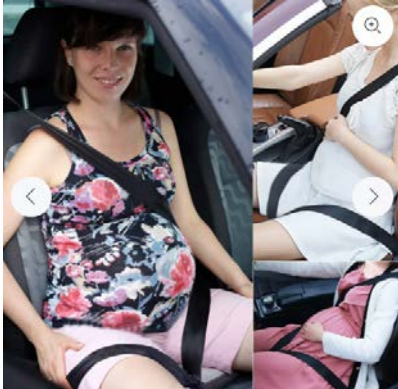


“Premium Belt”  
 “Doctor-Approved”  
 “Tested and Certified”  
 “Takes pressure off the stomach and redirects it to thighs ensuring your fetus remains safe”  
 “Dramatically reduces the chances of lost pregnancies in car accidents by over 82.7% compared to regular seatbelts”



# Comfort Products

- ▶ Re-direct belt away from abdomen



## Challenges:

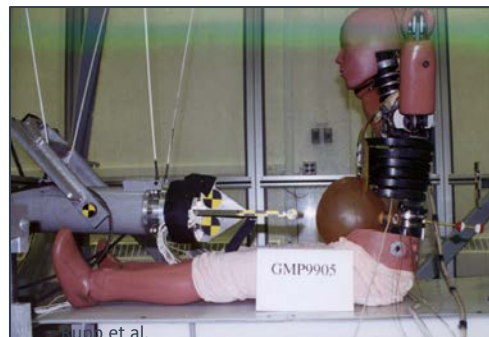
- Introduces slack into belt.
- Moves belt away from pelvis.



Anything that increases forward pelvis motion risks loading of steering wheel into abdomen (similar to an unbelted occupant)

# Pregnant Occupant Test Devices / Models

## MAMA-2B ATD



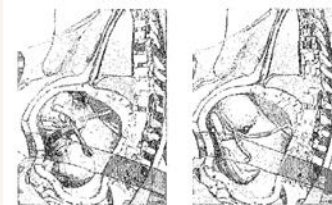
Supp et al.  
2001



THUMS v.1.0  
AF05

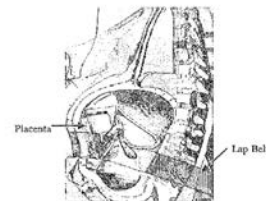


Kitagawa et al.  
2011



Case 1: Standard

Case 4: Fetus in Reverse Position



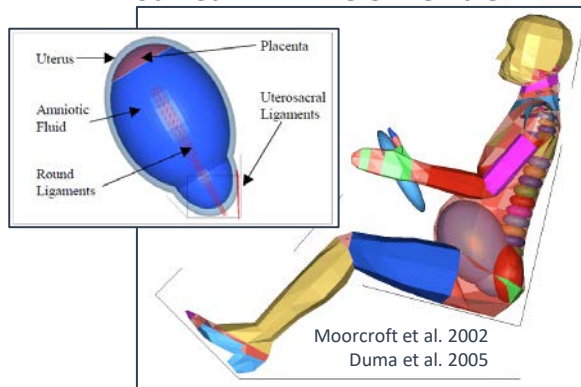
Case 5: Placenta at Anterior Uterus Wall

Gaps: No tools standardized or widely accepted.

Possible limitations:

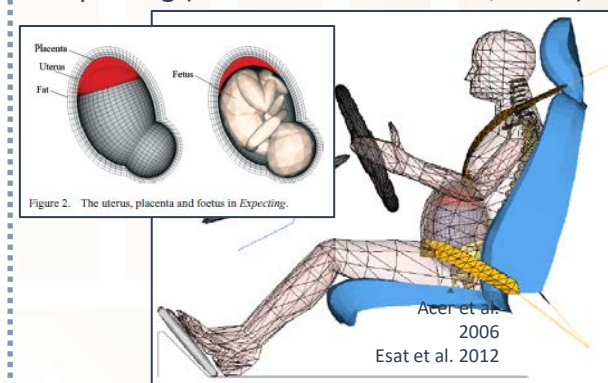
- Size (limited to 5<sup>th</sup>% females)
- External & internal shape
- Belt fit
- Intrauterine geometry, mechanics (for seated postures)

Modified MADYMO 5<sup>th</sup> female



Moorcroft et al. 2002  
Duma et al. 2005

Expecting (MADYMO 5<sup>th</sup> female w/ fetus)



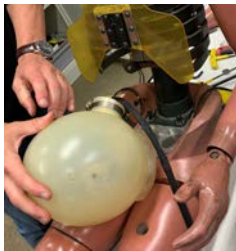
Acer et al.  
2006  
Esat et al. 2012



# Tests and Simulations at Autoliv



56 kph FF pulse.  
ATD: MAMA-2B (based on H-III5F).



Belly/  
uterus

Sled setup (reference)












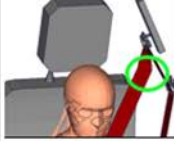


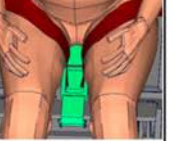


None resulted in overall safer performance

Most noticeably increased forward pelvis motion

This study was partly funded by Skyltfonden (TRV 2020/106841; TRV 2023/28059) held in trust by the Swedish Transport Administration.



# Tests and Simulations at Autoliv

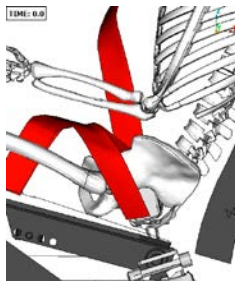
Picture								
Setup								



Pregnant 5th%  
SAFER HBM



Reference



Example  
comfort  
product

None resulted in overall safer performance  
Most noticeably increased forward pelvis  
motion

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# SUMMARY

- Pregnant automobile occupants represent a unique challenge for automobile safety
  - Unique injury types
  - Protection of both the mother and the fetus
  - Belt use perceptions and guidance
  - Belt fit
- Potential opportunity for improvement through...
  - Communication of importance of proper seatbelt use
  - Continuing study of risk factors for injury to mother and fetus
  - Development of safety assessment tools for range of pregnant automobile occupant sizes and gestational age

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