MAYO CLINIC

"Will that X-ray harm my unborn child": *A meta-analysis of fetal health effects indicates very low risk to fetus following occupational exposure of pregnant interventional physician.*

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LEADING THROUGH CHANGE

Disclosures

- Authors have no disclosures to declare.

Educational objectives

- Comprehensive literature review-collected and combined into one source.
  - Review of fetal risk levels
    - radiation dose (occupational radiation exposure)
    - maternal body mass index (BMI)
    - maternal age
    - hormonal therapy during the pregnancy

- Provide literature-based insight which cardiologists and radiologists can use to guide career decisions.

Take home message

- For our interventional cardiologists and radiologists with proper radiation safety practices, fetal radiation dose is predicted to be < 4 mGy per term.

- Compared with known risk of early childhood cancer from other causes, the predicted risk of cancer associated with estimated fetal radiation dose is very low.

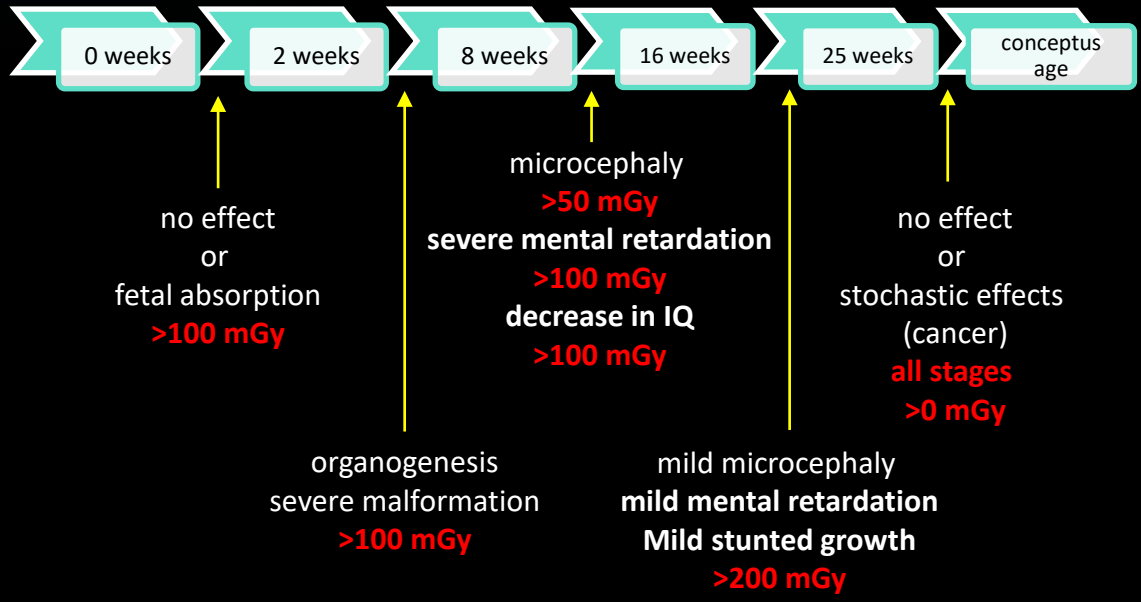
Radiation dose defined

- International convention is to express dose to the human fetus in units milli-Gray (mGy), and this convention will be followed herein.
  - Radiation dose to human tissue is assigned units milli-Gray (mGy).
  - Whole body “effective dose” is assigned units milli-Sievert (mSv).
    - *In US regulations, the fetus dose limit is specified in units mrem, where 100 mrem = 1 mSv.*

Deterministic/Stochastic effects

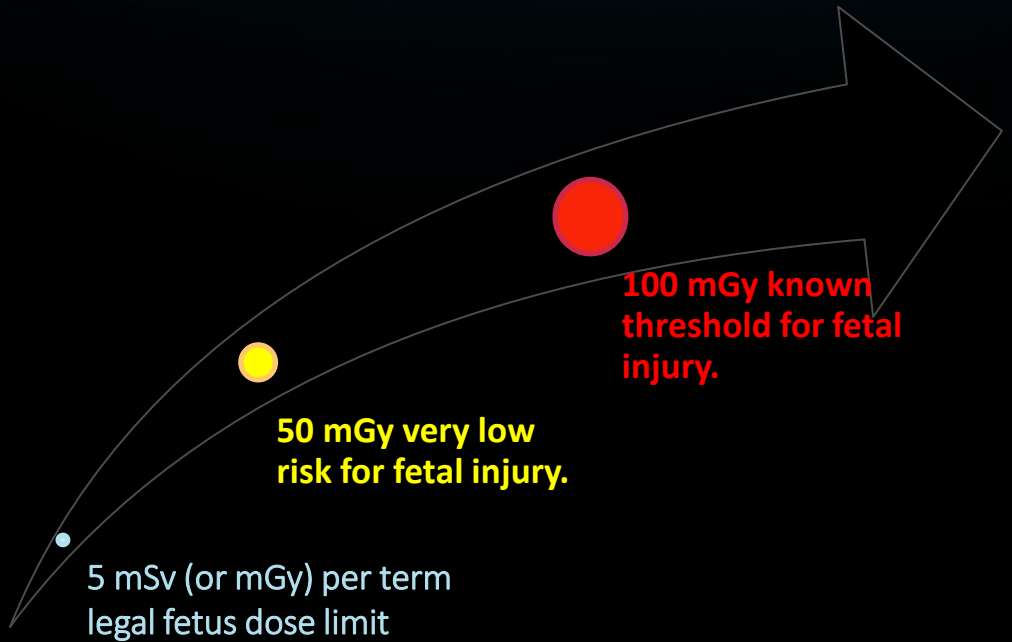
- Known fetal risks following high fetus radiation dose:
  - prenatal death
  - small head size
  - mental retardation
  - congenital malformation and
  - childhood risk of cancer

Summary of biological effects of prenatal radiation exposure taking in account time point of exposure related to conception as well as the threshold value of risk.



** adapted from Wagner, et al.*

Putting risks numbers into perspective…



- Exposure to high doses of radiation are known to be detrimental to the health of the fetus.
- Considering the necessary radiation exposure threshold for tissue effect to potentially occur is much higher that what an interventional cardiologists/radiologists would receive.

**ICRP 84 "Pregnancy and Medical Radiation"*
** NCRP 54 "Medical radiation exposure of pregnant and potentially pregnant women"*

Background

- As a rapidly evolving field interventional cardiology has advanced remarkably since its inception ~50 years ago.
- Yet, throughout the world, there is a major underrepresentation of women in interventional cardiology (IC).
- Nonuniformity of the guidelines and often inconclusive data related with fetus health risk continues to be an important factor for women considering careers in IC.

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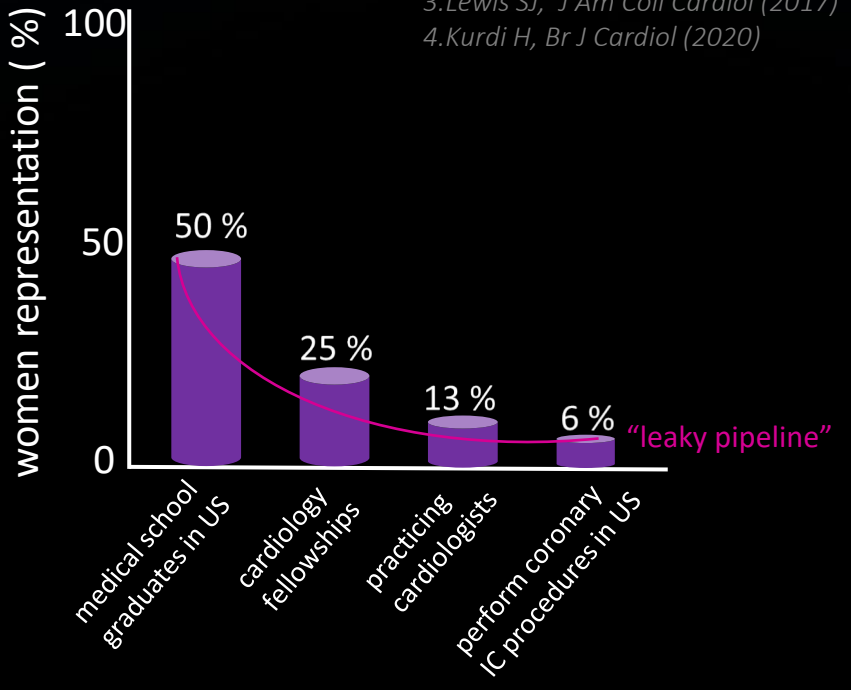
2.Douglas PS, JAMA Cardiol (2018)
3.Lewis SJ, J Am Coll Cardiol (2017)
4.Kurdi H, Br J Cardiol (2020)



Estimating fetus dose in our practice

- Occupational exposure values (E, mGy) as measured at the left collar, outside the apron for working groups, radiologists and cardiologists, per year.

  $E_{collar, ave.}$ = 18.5 mGy, (N = 191)
  Range: 0.5 – 46.1 mGy

- Multiply by 2 to estimate exposure at the abdomen, outside the apron.

  $E_{abd., outside}$ = 36.9 mGy

- Estimate abdomen exposure inside a 0.5 mm Pb apron, assuming 3 % transmission.

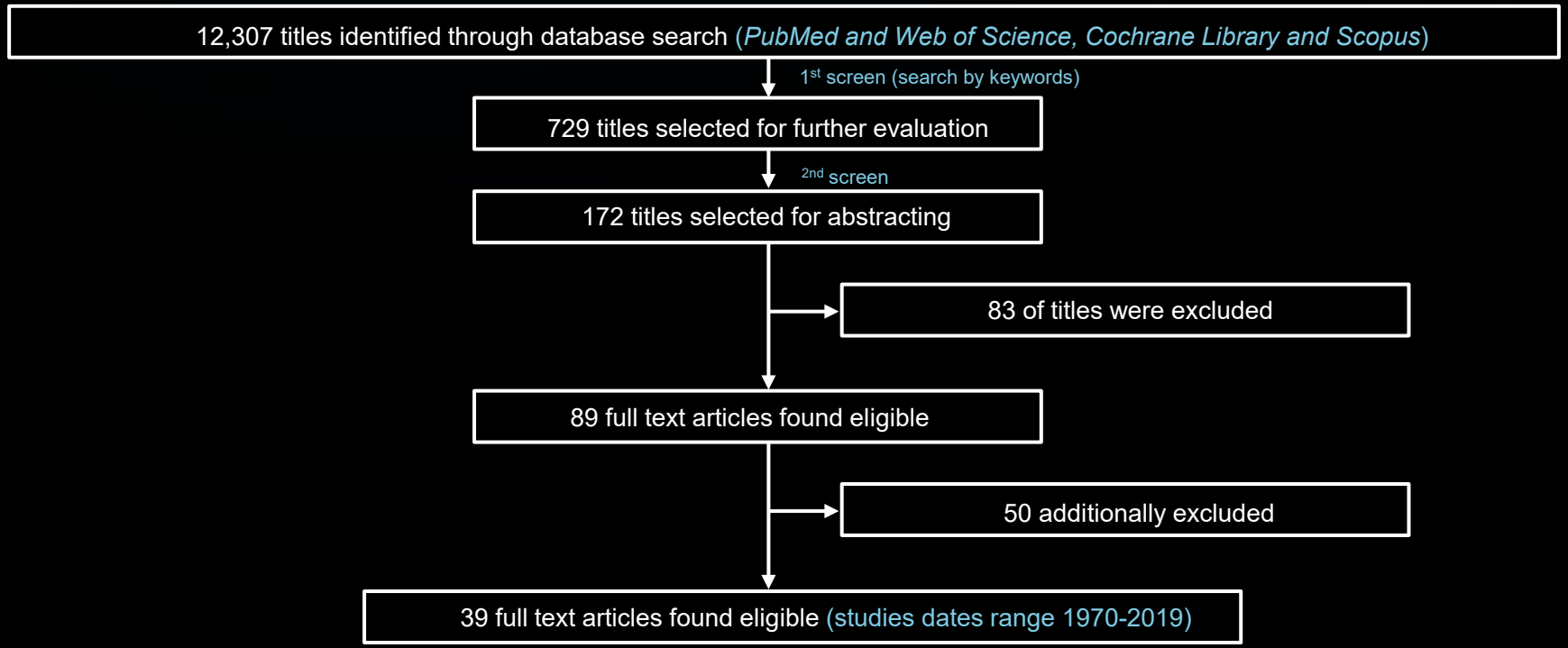
  $E_{abd., inside}$ = 1.1 mGy

- Assign exposure under the apron as conservatively high estimate of fetus dose (D).

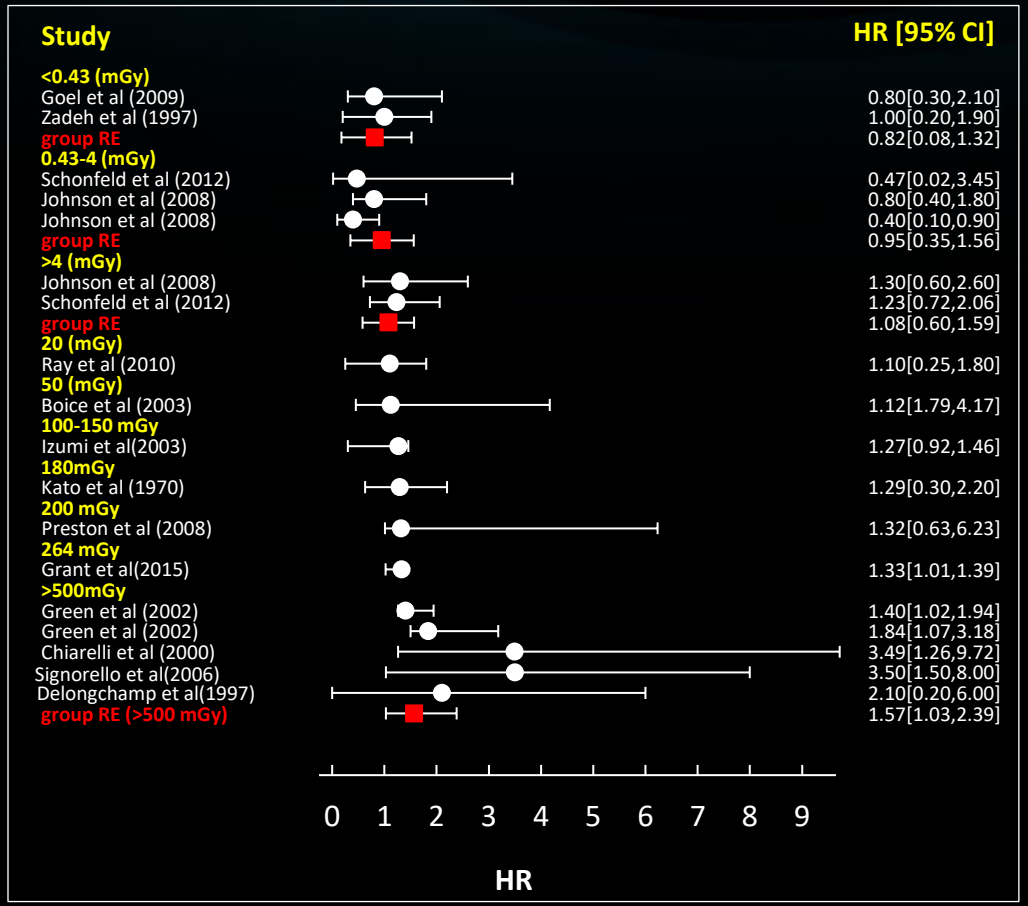
  $D_{fetus} \approx$ 3.9 mGy (mSv)

**In dose estimations use of upper and lower body shield is assumed*

Material and methods

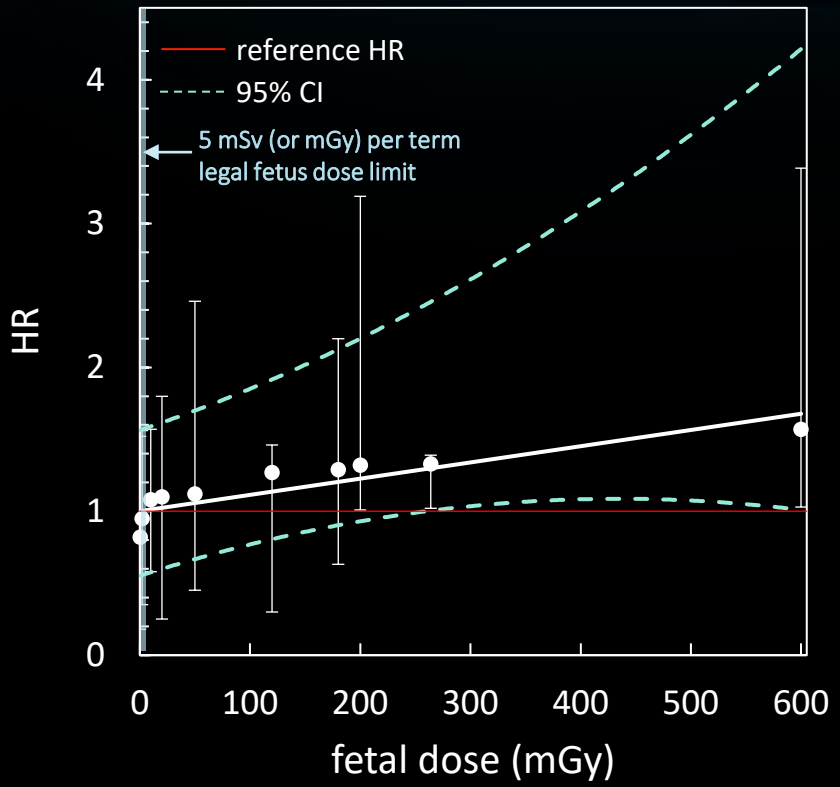


Results: Meta-analysis of maternal exposure to radiation and early childhood cancer risk



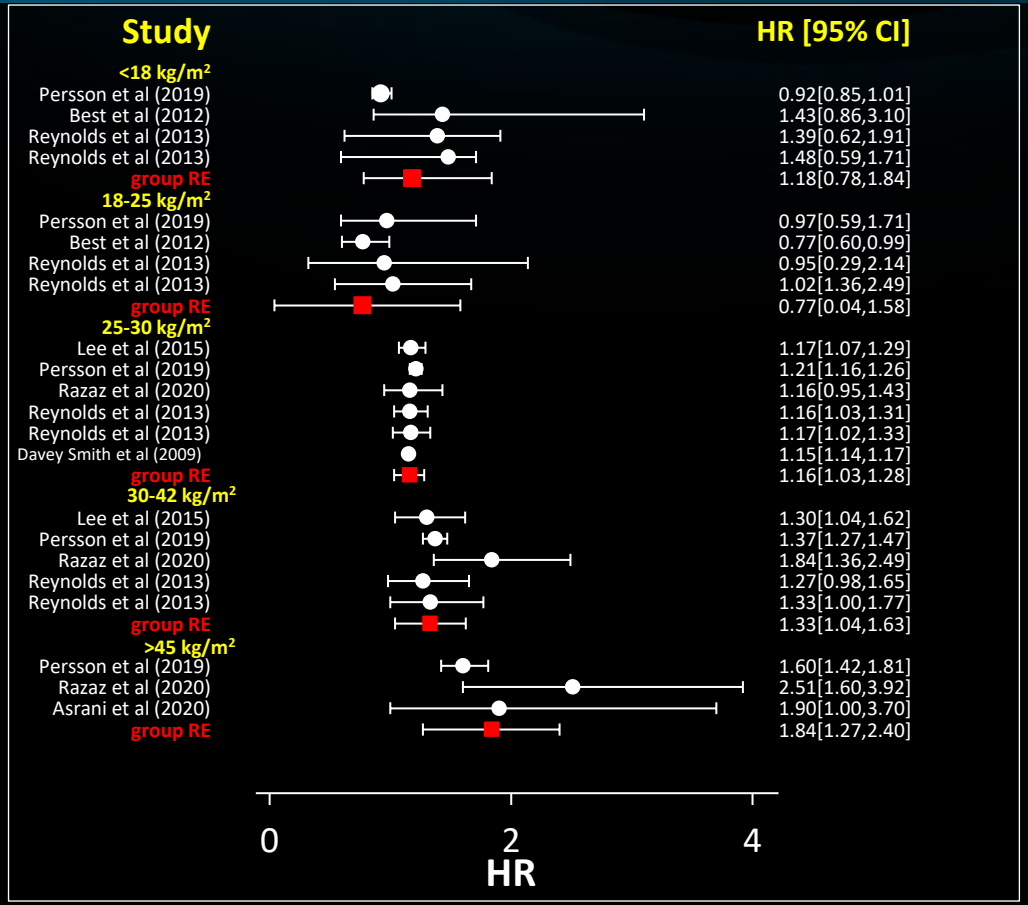
Pooled data using random effect model showed that risk of developing early childhood cancer increase with dose.

Results: Meta-analysis of maternal exposure to radiation and early childhood cancer risk



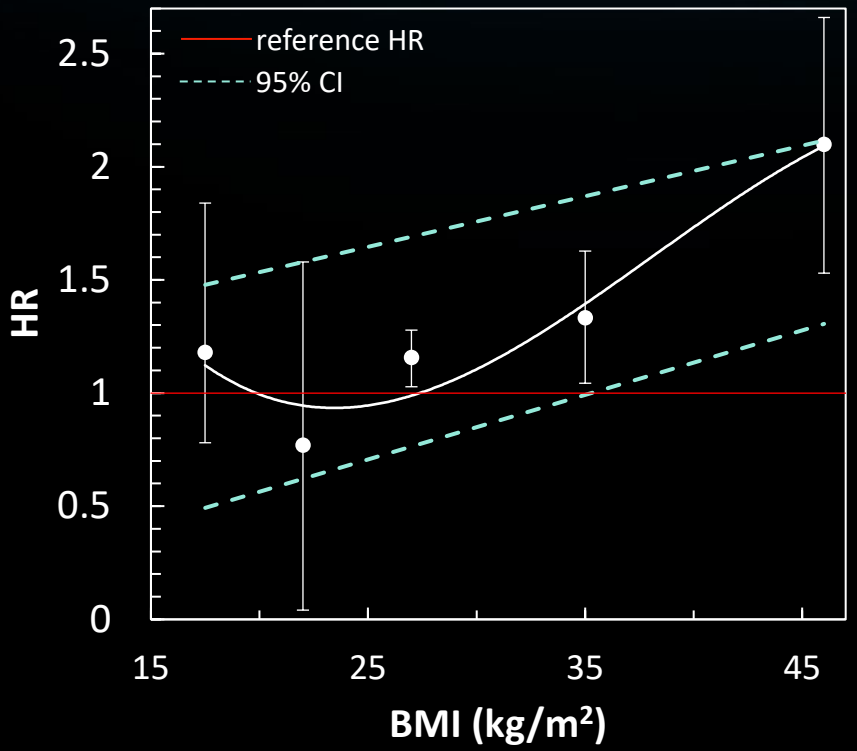
- This meta-analysis suggests that fetus dose greater than ~200 mGy may be associated with increased risk of adverse health effect.
- Other works have suggested that fetus dose >100 mGy may be associated with increased risk.
- Importantly, this meta-analysis demonstrates that HR for fetus dose < 5 mGy is not different than for dose of 0 mGy; HR = 1.001 [95% CI 0.8 to 1.09, p=0.967].

Results: Meta-analysis of maternal body mass index and risk of congenital heart defects in infants



Meta-analysis among the observational studies showed that maternal BMI is associated with increased risk of CHD in infants.

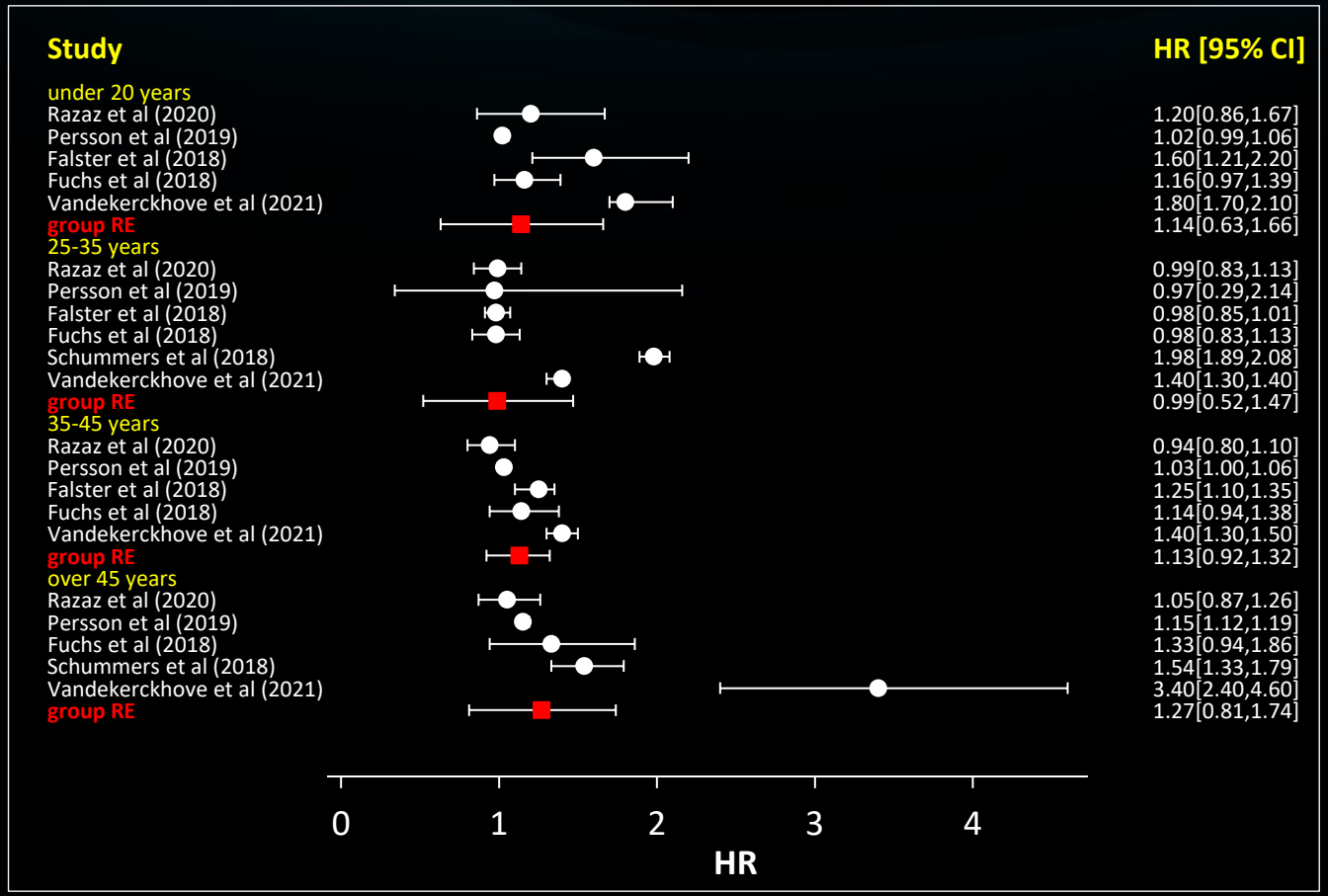
Results: Meta-analysis of maternal body mass index and risk of congenital heart defects in infants



Maternal BMI index and hazard risk for CHDs in infants have indicated a positive effect of:

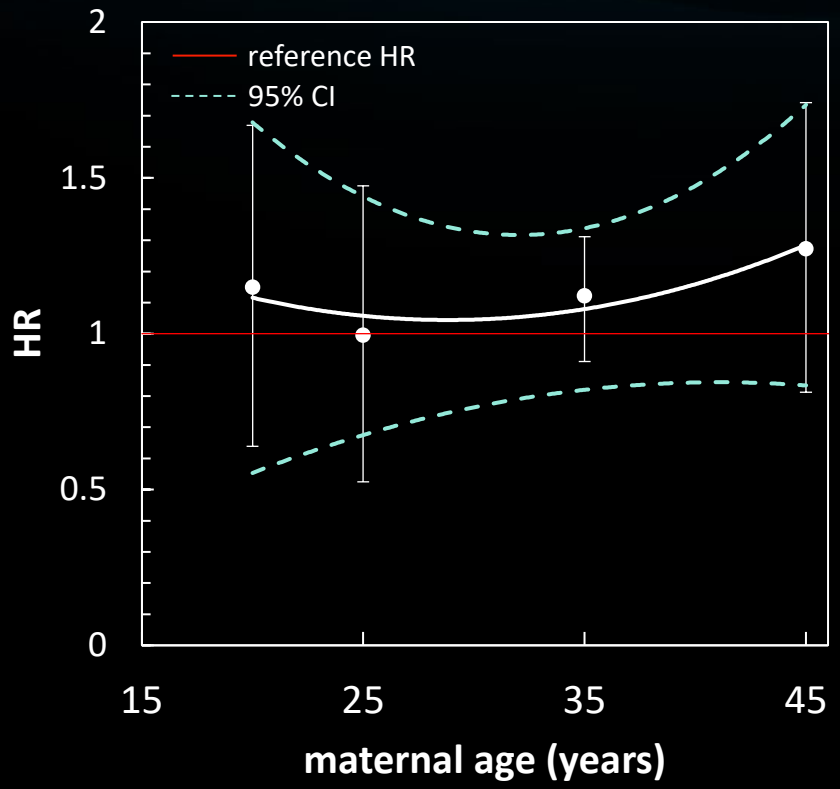
- maternal overweight (BMI >30 kg/m^2), HR 1.33 [95% CI 1.04, 1.63, p=0.03],
- underweight mothers (BMI <18 kg/m^2), HR 1.18 [95% CI 0.78, 1.84, p=0.04].

Results: Meta-analysis of maternal age on preterm birth and low weight newborns



Meta-analysis showed age gradient in the probability of giving preterm birth and a low-birth-weight child and was higher at maternal ages older or younger that at the reference category ages (25-35 yrs).

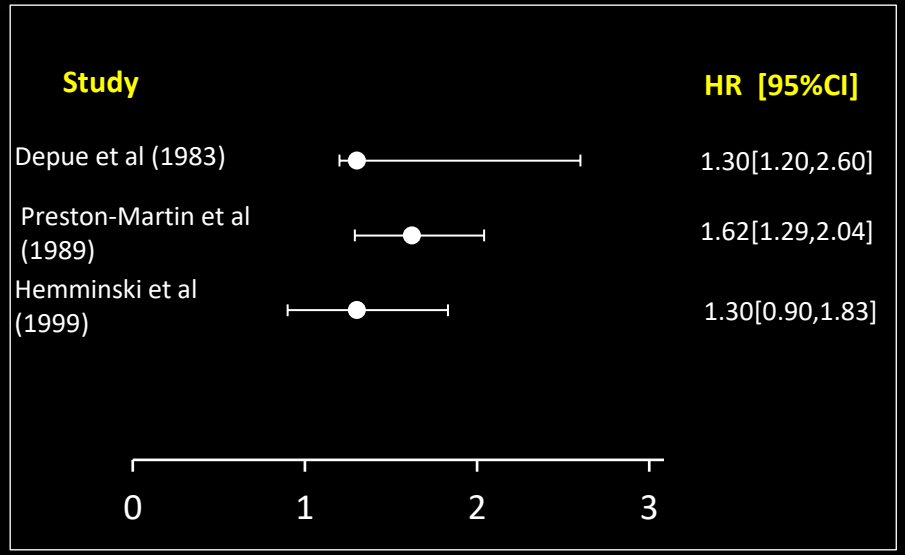
Results: Meta-analysis of maternal age on preterm birth and low weight newborns

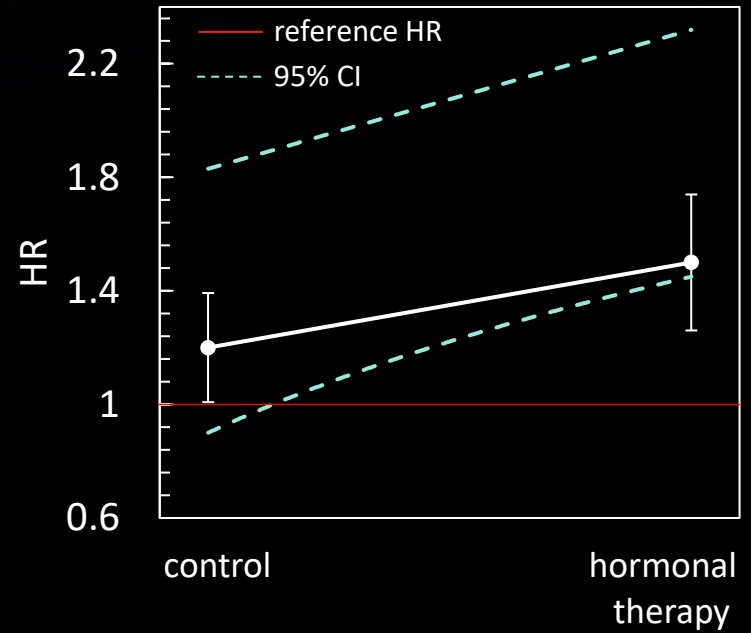


Meta-analysis showed age gradient in the probability of giving preterm birth and a low-birth-weight child and was higher at maternal ages older or younger that at the reference category ages (25-35 yrs).

- (age < 18 yrs HR 1.14 [95%CI 0.63, 1.66, p=0.06)
- (age > 45 yrs HR 1.27 [95% CI 0.81, 1.74, p=0.08)

Results: Meta-analysis of exposure to female hormone drugs during pregnancy and its effect on malformation in male children





Performed meta-analysis supports hypothesis that oestrogen/progestin drug therapy during pregnancy brings increased risk of malformations in children who were exposed in utero (HR 1.4 [95% CI 0.85, 1.75]. HRs were higher among exposed male children compared to control.

Summary

1. The meta-analysis demonstrates that HR for fetus dose < 5 mGy is not different than for dose of 0 mGy; HR = 1.001 [95% CI 0.8 to 1.09, p=0.967].

2. Maternal BMI > 30kg/m^2 was associated with HR 1.33 [95% CI 1.04, 1.63, p=0.03], increased risk in CHD in infants.

Summary

3. Maternal age > 45 years increases risk of preterm birth and underweight newborn with estimated HR 1.27 [95% CI 0.81, 1.74, p=0.08].

4. Hypothesis that oestrogen/progesterone drug therapy during pregnancy brings increased risk of malformation in male children who were exposed *in-utero,* HR 1.4 [95% CI 0.85, 1.75, p=0.08].

Conclusions

- This meta-analysis of 14 studies of childhood cancer incidence following in-utero radiation exposure indicates that even dose less than ~200 mGy is not associated with adverse health effect. This finding agrees with others that fetus dose less than 100 mGy is unlikely to be associated with adverse health effects.

- In our practice, dose to the fetus of interventional cardiologists and radiologists is expected to be less than 4 mGy.

- This work supports the position that radiation risk to the fetus of an interventional physician is exceptionally low.

- Factors that adversely affect the gestational and early postnatal environment such as maternal BMI, age and some disease treatments can significantly alter fetal development with persistent effects on health.

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