Endocrine Disrupting Activity Associated With Oil and Natural Gas Extraction

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NIH R21ES026395 and R01 ES021394, The University of Missouri, EPA STAR Fellowship (Kassotis)
Routes of contamination of surface and ground water with oil and gas wastewater
Routes of contamination of surface and ground water with oil and gas wastewater

- Spills
- Runoff
- Leaks
- Air
- Casing Failure
- Deep Connectivity

Riha and Rahm (2010)
1. Can chemicals used in unconventional oil and gas (UOG) operations disrupt normal endocrine signals?

2. Is there evidence of an association between oil and gas activities and human reproduction?

3. Does perinatal exposure to a mixture of oil and gas chemicals alter adult health?
Hormones are chemical messages essential for normal health and development.
Hormone work by binding to specific receptors
Endocrine Disrupting Chemicals (EDC)

“A chemical, or mixture of chemicals, that interferes with any aspect of hormone action.”

The Endocrine Society Statement on endocrine disrupting chemicals. Endocrinology 2012
Can chemicals used in unconventional oil and gas (UOG) disrupt normal hormone signals?

<table>
<thead>
<tr>
<th>Chemical</th>
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</thead>
<tbody>
<tr>
<td>1,2,4-trimethylbenzene</td>
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## EDC Activity of 23 UOG Chemicals

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Activation</th>
<th>Inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estrogen</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Androgen</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Progesterone</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Glucocorticoid</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Thyroid</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

*Kassotis et al 2014 and 2015, Endocrinology*
Disruption of Hormones Is Associated with Human Disease

- Estrogen
- Androgen
- Glucocorticoids
- Progesterone
- Thyroid

Related Diseases:
- Cancer
- Metabolic Syndrome
- Immune Disorders
- Infertility
- Altered Puberty
- Reproductive Problems
- Neurological Issues
- Behavioral Disorders
- Organ Defects
1. Can chemicals used in unconventional oil and gas (UOG) operations disrupt normal endocrine signals?

2. Is there evidence of an association between oil and gas activities and human reproduction?

3. Does perinatal exposure to a mixture of oil and gas chemicals alter adult health?
Systematic review of the association between oil and natural gas extraction processes and human reproduction

Victoria D. Balise, B.S., Chun-Xia Meng, M.D., Ph.D., Jennifer N. Cornelius-Green, M.S., Christopher D. Kassotis, Ph.D., Rana Kennedy, B.S., and Susan C. Nagel, Ph.D.

Department of Obstetrics, Gynecology and Women's Health, and Division of Biological Sciences, University of Missouri, Columbia, Missouri; and Nicholas School of the Environment, Duke University, Durham, North Carolina
1814
Met our search Criteria

Nonduplicates
N = 1719

442
Related to Oil and Gas

417
Not related to Oil & Gas
N = 1277

442
Related to Oil and Gas

Reproduction or Perinatal Exposure
N = 237

232
Not Reproduction Or Perinatal Exposure
N = 205

29
Nonhuman
N = 174

63
And Human Reproduction

29
Nonenglish Language or Full text not available
N = 2

61
English Language & Full text available
N = 61

45
And Original Research

16
Review Articles
N = 16
Studies were assessed for quality of evidence and risk of bias and then the evidence was integrated.

- Effect High Number of Studies X 3
- Effect Moderate Number of Studies X 2
- Effect Low Number of Studies X 1
- No Effect High Number of Studies X 3
- No Effect Moderate Number of Studies X 2
- No Effect Low Number of Studies X 1
Birth Outcomes Associated with Oil and Gas Activities

- **Miscarriage**
  - Total: 3
  - **Effect High**: Majority
  - **Effect Moderate**: Small portion

- **Stillbirth**
  - Total: 2
  - **No Effect Moderate**: Majority
  - **No Effect Low**: Small portion

Balise et al. 2016, Fertility and Sterility
Birth Outcomes Associated with Oil and Gas Activities

Preterm Birth
Total=8*

Low Birth Weight
Total=6

Effect High
Effect Moderate
Effect Low
No Effect Moderate
No Effect Low

Balise et al., 2016: Fertility and Sterility
Birth Outcomes Associated with Oil and Gas Activities

Birth Defects

- Total = 3
- Effect High: 2
- Effect Moderate: 1
- Effect Low: 0

Sex Ratio

- Total = 2
- No Effect: 1
- Moderate: 1

Balise, et al., 2016, Fertility and Sterility
Male Reproductive Health Associated with Oil and Gas Activities

Semen Quality and Fertility
- Effect High
- Effect Moderate
- Effect Low

Total=4

Paternal Birth Outcomes
- No Effect Moderate
- No Effect Low

Total=2

Prostate Cancer
- Effect High
- No Effect Moderate
- No Effect Low

Total=4**

Balise, et al, 2016, Fertility and Sterility
Evidence from Systematic Review that UOG Chemicals can be Endocrine Disruptors

Balise, et al, 2016, Fertility and Sterility
1. Can chemicals used in unconventional oil and gas (UOG) operations disrupt normal endocrine signals?

2. Is there evidence of an association between oil and gas activities and human reproduction?

3. What health effects may be associated with prenatal exposure to chemicals?
Fetal and early life exposure to EDCs is associated with adult disease

Pollutants

Nutrition

Maternal Health and Disease

Infertility
Obesity
Heart Disease
Diabetes
Hypertension
Hyperactivity
Bone Health
Endometriosis
Breast Cancer
Testicular Cancer

BodyBurden: The Pollution in Newborns
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Developmental exposure to a mixture of 23 UOG chemicals via drinking water

Vehicle 0.2% ethanol
Mix 1 3000 µg/kg
Mix 2 300 µg/kg
Mix 3 30 µg/kg
Mix 4 3 µg/kg

Exposure was equivalent to roughly the second trimester of human pregnancy.

Prenatal exposure* to UOG mixture did not alter number of pups per litter

* Exposure equivalent to 2nd trimester of human pregnancy

Health Effects in Male Offspring
Prenatal exposure to UOG mixture altered body and organ weights in adult male mice

Kassotis et al 2015, Endocrinology

Ground water directly below surface spills, Gross et al

Kassotis et al 2015, Endocrinology
Prenatal exposure to UOG mixture increased adult testosterone and decreased sperm counts.
Health Effects in Female Offspring
Prenatal Exposure Decreased Reproductive Hormones: Prolactin and FSH

Kassotis, et al 2016, Endocrinology
Prenatal Exposure Decreased LH and Increased GH

Kassotis, et al 2016, Endocrinology
Prenatal Exposure Increased Number of Atretic Follicles at Low Doses

(E) Prepubertal (3 weeks old)

(J) Adult (3 months of age)

Kassotis, et al 2016, Endocrinology
Collagen deposition was increased in the heart at low doses.
Conclusions

• Many chemicals used in and produced by oil and gas activities can be EDCs.
• A systematic review of published studies suggests there is evidence for an association between oil and gas activities and negative developmental and reproductive health effects in humans.
• Laboratory studies found an association between prenatal exposure to UOG chemicals and negative developmental and reproductive health outcomes.