Environmental Contributions to Healthy Fatherhood

Reducing risk while promoting health equity

Sally Perreault Darney, Ph.D.
Office of Research & Development
Sustainable & Health Communities Research Program

Racial and Ethnic Disparities in Pregnancy Outcomes: Exploring the Role of Paternal Involvement

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Today's Objective

Theme:

- How do environmental factors influence father-mediated fecundity and birth outcomes?

Focus:

- Chemical stressors in the workplace and ambient environment which may impact male reproductive potential;
- Potential for "take home" exposures by Dad;
- Equity: Are men in lower SES at disproportionate risk of higher, potentially hazardous exposures because of where they live and work?
- Can public health messaging be directed at prospective fathers to improve health literacy and promote healthy fatherhood?

National Health Strategies

EPA Strategic Plan 2011-15: "Working for Environmental Justice and Children's Health"
We must include environmental justice principles in all of our decisions…The protection of vulnerable populations is a top priority, especially with regard to children. Lisa P. Jackson, 2010

HHS Healthy People 2020
Set the elimination of health disparities* and achieving health equity as top national priorities. EPA's research aims to understand and prevent health disparities from environmental conditions and pollution.

National Prevention Strategy, 2011, includes "Eliminating Health Disparities".

***Health Disparity:** *a particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage.*

Recognition that health and well-being are determined by many interacting factors

Inherent Factors (Host) Determine susceptibility:

- Age/lifestage/gender
- Genetics & epigenetics
- Pre-existing disease

  Diabetes, developmental deficits, cardio-vascular disease; "resilience"

Environmental Factors

- Exposures to pollution and chemical hazards in environment: Home, School, Workplace, Outdoor
- Natural Environment -- Temperature/Climate

Social & Economic Factors-- Individual choices/behaviors:

- Diet and exercise
- Habits and lifestyle
- Education
- Occupation

Social & Economic Factors-- Community based & cultural:

- Family values and lifestyle
- Social stressors: Poverty, racism, crime; discrimination
- Neighborhood conditions
- Access to healthy food, medical care, safe workplace

How does this apply to prospective fathers?

From an *environmental health* standpoint, fathers can impact birth outcomes in several ways:

- PRECONCEPTION: Direct impacts of environmental hazards on sperm may result in:
  - Lack of fertilization (infertility)
  - Damaged sperm DNA (miscarriage, birth defects and deficiencies)
- PRE- and POST CONCEPTION: Father may contribute exposures to prospective or pregnant woman
    - Behaviors affect home environment, e.g. smoking, use of paints/solvents, etc.
    - “Take home” from work (pesticides, lead)
    - Pharmaceuticals and other contaminants in semen: vaginal transmission to female

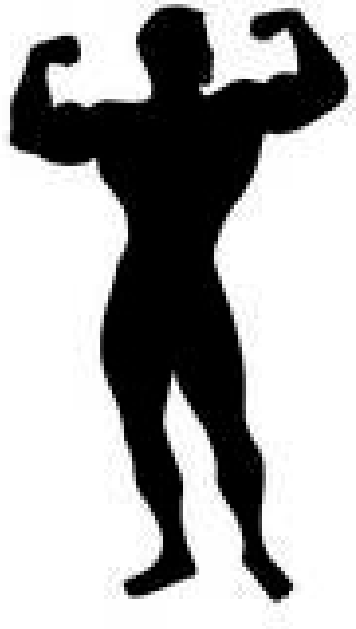
Focus on most relevant environmental factors for prospective fathers

Inherent Factors (Host) Determine sperm quality & susceptibility:

•Genetics & epigenetics – **Protective mechanisms**

•Pre-existing disease

Mumps/fever, endocrine imbalance, STDs, cancer Rx, stress



Environmental Factors

•Exposure to chemical hazards at work (NIOSH, EPA)

•Potential hazards at home?

•Exposure to hot outdoor environments?

• **Severe air pollution (EPA)**

Social & Economic -- Individual choices/behaviors:

•Diet – Antioxidants?

•BMI/Obesity?

•Smoking, Drugs & Alcohol?

•Education~SES, job, complex exposures?

Social & Economic -- Community & cultural:

•Social stressors: Poverty, racism, crime; discrimination?

•Neighborhood conditions

•Access to healthy food, medical care, safe workplace?

Male Reproductive Health Effects – Occupational and Environmental Exposures of Concern

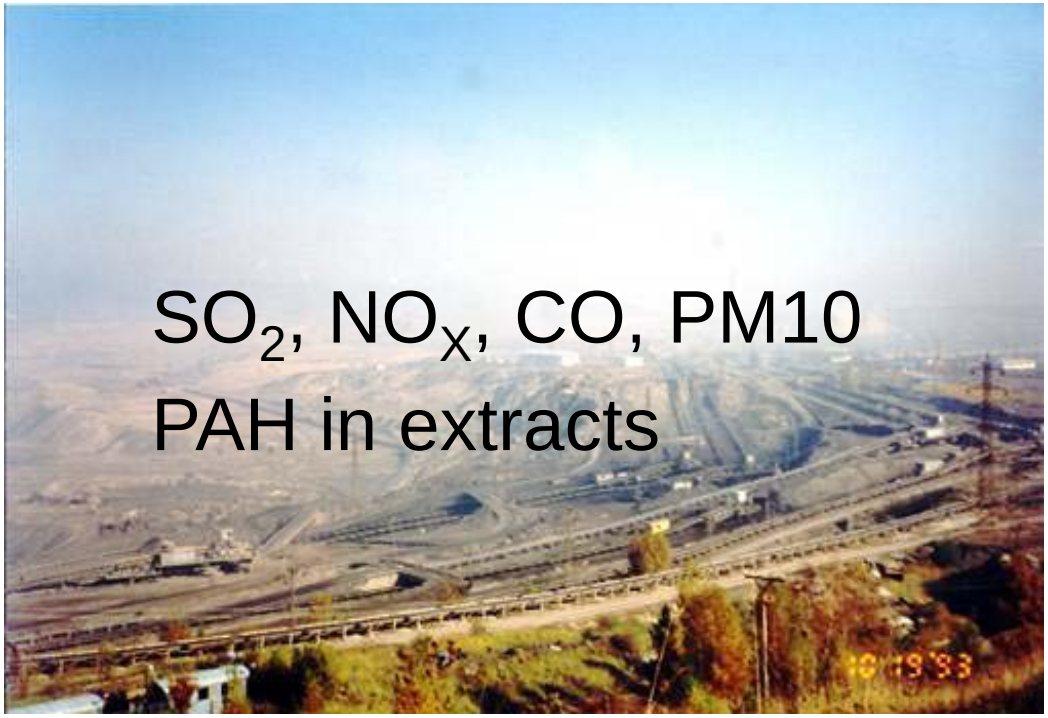
- Impacts on semen quality (predictive of fertility)
  - Heavy Metals
    - e.g. lead, cadmium, nickel
  - Pesticides
    - e.g. DBCP, EDB, Carbaryl (Sevin)
  - Solvents
    - e.g. Glycol ethers, perchloroethylene
  - Industrial chemicals
    - e.g. Spray adhesive bromopropane
  - Heat

Male Reproductive Health Effects – Occupational and Environmental Exposures of Concern

- Genetic Damage to the Sperm
  - Spontaneous Abortions
    - Organic Solvents
    - Aromatic Hydrocarbons
    - Petroleum Refinery Chemicals
  - Birth Defects
    - Paints – Cleft Palate
    - Printing Industry –Cleft lip
  - Sperm Chromatin Damage
    - Severe Air Pollution, Organophosphorous Pesticide
  - Sperm Aneuploidy
    - Organophosphorous Pesticide
    - Boron (in miners)

Example: Air Pollution and Semen Quality

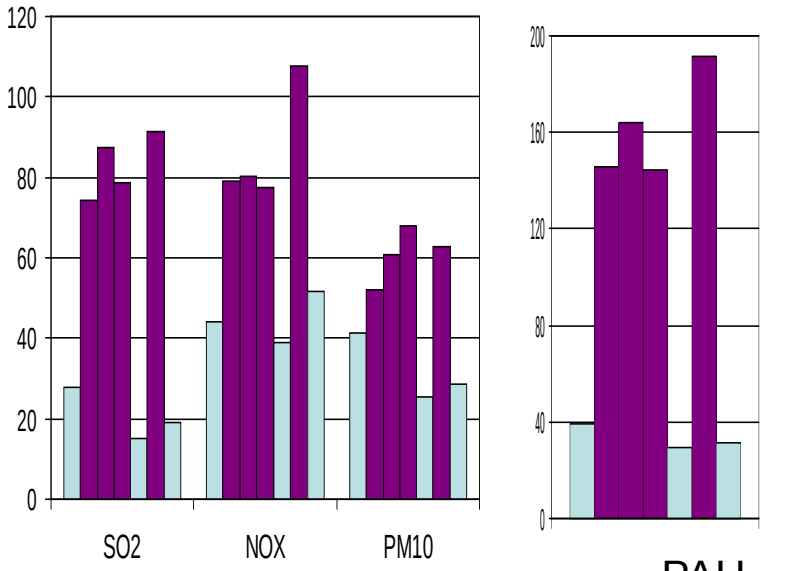
Rubes et al 2005, 2007



- Exposure: Air pollution in Teplice, CZ originating from coal mining and used locally for both industry and home heating.
- Pollution high (above standards) in winter but not summer

Longitudinal Design: Healthy young (18-22 yr) men evaluated after high and low exposures over two years

Exposure calculated for 90 days Preceding semen sampling



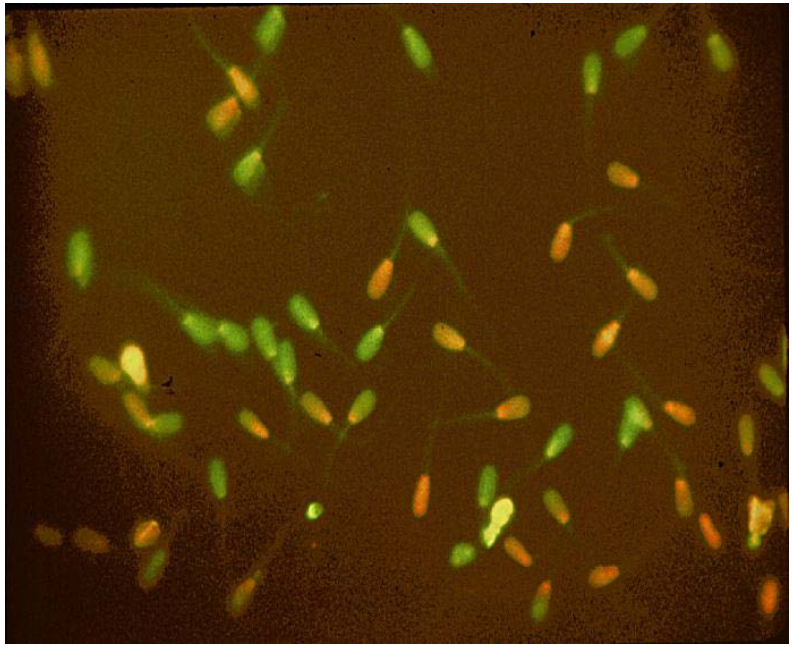
Purple = winter; blue = summer

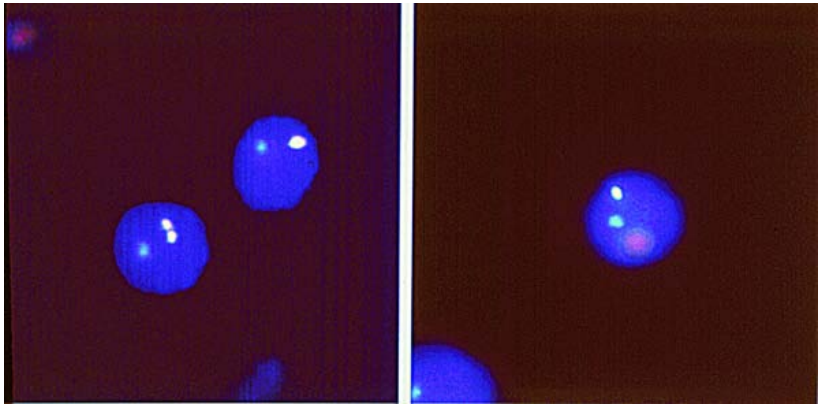
Physical exam & semen sample
Questionnaire: life style, job history and general health;
Longitudinal analysis

Outcomes: Semen analysis and Sperm Genetic Integrity

Sperm count, concentration, Motility and morphology

Sperm Aneuploidy





DNA damage

(Sperm Chromatin Structure Assay)

Also:
Metals in blood
Genotyping

Results and Conclusions

United States Environmental Protection Agency

- Exposure to episodes of severe air pollution was associated with increased sperm DNA damage (without changes in other outcomes).
- Gene-environment interaction: Increased sperm DNA damage was seen only in men with a genetic variation that diminishes their ability to detoxify reactive chemicals in air pollution. (GST M1 null polymorphism).
- The analysis controlled for life style and work but could not separate smoking and drinking alcohol (correlated in this group)
- Results are suggestive of risk for adverse pregnancy outcomes, but study was not designed to evaluate linkage with fertility or birth outcomes.
- Temporal pattern suggests damage is mainly to mature sperm and therefore transient after acute exposures.
- Implications for smokers and men living/working in areas of high air pollution (e.g. toll collectors)

Methodological challenges: Determining role of male when evaluating birth outcome as the health indicator

- Need comprehensive exposure assessment. Ambient levels may misclassify exposure but personal monitoring is more labor intensive and expensive; better biomarkers are needed.
- Toxicants may impact both sexes but in different ways and at different critical windows.
- Attribution of adverse pregnancy outcomes to men may not be feasible: exposures rarely limited to man before conception, and often occur to both partners before and during pregnancy…especially with complex exposures in community settings.
- Use of semen outcome as health indicator is male-specific but not necessarily predictive of birth outcomes.

Man's exposures may be transferred to woman

- Transport of Chemicals Transvaginally from Semen
  - Heavy Metals
    - e.g. Lead, Nickel, Cadmium
  - Pesticides
    - e.g. 2,4 D, EDB
  - Solvents
    - e.g. Benzene, Xylene. Trichloroethylene
  - Phamaceuticals
    - e.g. chemotheurapeutics, illegal drugs

Father may influence exposures at home

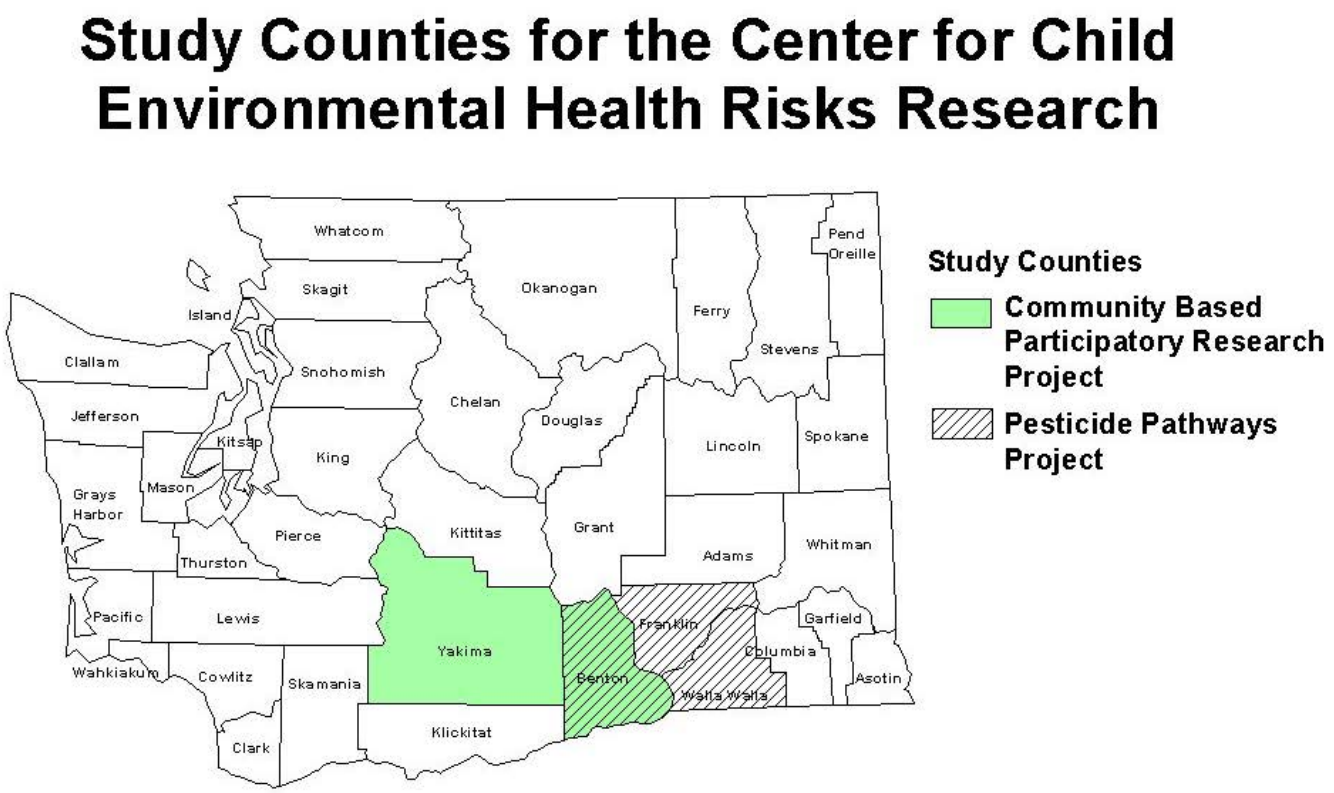
- Environmental tobacco smoke
- Chemicals used at home: paint, solvents, pesticides, herbicides
- “Take home” exposures from work on clothing and skin

Take-home Pathway for Agricultural Pesticides: Yakima Valley Experience

Elaine M. Faustman, Ph.D. DABT
Professor and Director
Institute for Risk Analysis and Risk Communication
Center for Child Environmental Health Risks Research

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Comparing Farmworker and Non-Farmworker Exposures



Longitudinal sampling design

- **Multiple seasons: thinning, harvest, and off season**
- **Repeated sampling within the seasons**
- **Metabolites of Organophosphate pesticides measured:**
  - Nonspecific Diakyl Phosphate (DAP) metabolites
    - Dimethyl metabolites
    - Diethyl metabolites
  - Specific metabolites
    - Chlorpyrifos metabolites
    - Chlorpyrifos-methyl metabolites
- **Environmental samples**:
  - Household dust
  - Vehicle dust
- **Biosamples:**
  - Urine
  - Blood
  - saliva
- **Genetic samples:**
  - Buccal cells
  - Lymphocyte buffy coat

“Take-home” pathway contributed to children’s exposures

- **Farmworkers**, who do not directly use pesticides, had higher levels of organophosphate pesticide exposure than **non-farmworkers**.
- **Workers** who thinned were more likely than others to have certain residues in their house dust and vehicles.
- **Children** of farmworkers had significantly higher levels of certain urinary metabolites compared to children of non-farmworkers.
- **Intervention study:** measures to reduce the take-home pathway (e.g. removing work boots before entering the home) can reduce potential exposure to families and children.
- **Note**: Not specific to male farmworkers

Do environmental and socio-economic factors *interact* and produce health disparities for men of low SES?

Living in communities "over-burdened" with complex exposures

Working in jobs located near sources of pollution

Public health challenges

- Health literacy: may be limited in men with lower education and SES
- Male attitudes towards their own health, including assumption that father does not determine baby's health
- Immigrant populations – illegal employment, use of personal protective equipment, ability to read safety precautions on products
- Lack of public health tracking data for fertility/fecundity, especially for specific groups/places
- Semen studies are difficult to conduct and often do not evaluate sperm DNA damage. Semen measures are indirect indicators of health outcomes.
- Lack of health screening exam for prospective fathers, and public health messaging designed for them.

Taking action

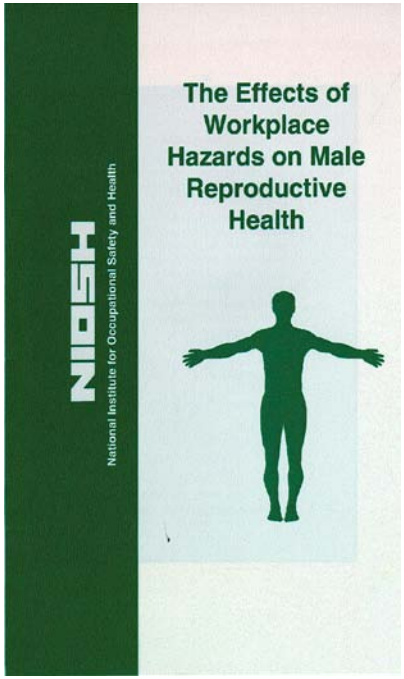
Safety assurance through regulations & enforcement in communities and workplaces.

Workplace screening for adverse effects on semen? (need better markers such as SCSA)

Medical care providers: Include environmental assessments in infertility workups, both primary and in cases of repeated miscarriage

Public Health: Promote preconception health education for men as well as women, and increase awareness of role of fathers in birth outcomes. e.g. Men's Health Alliance: http://www.talkingaboutmenshealth.com/ see "the sperm project"

Additional Resources



NIOSH: 1-800-CDC-INFO

- E-mail to: pubstaft@cdc.gov
- http://www.cdc.gov/niosh/docs/96-132/

NIEHS: monographs on potential reproductive and developmental effects of selected chemicals (bromopropane, acrylamide, phthalates, etc). www.niehs.nih/gov click National Toxicology Program to find links to CERHR/OHAT

Collaborative on Health and Environment
http://www.healthandenvironment.org/initiatives/fertility/fertility_resources

My Contact information: Darney.sally@epa.gov;
Environment, Health and Society www.epa.gov/ncer/ehs (focus on environmental justice)

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