Adverse Fetal and Childhood Health Effect of In-Utero Exposure to Magnetic Fields Non-ionizing Radiation

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Story of EMF Health Effect

• Discovery in 1979:
  – Nancy Wertheimer and Ed Leeper findings
  – Their incredible luck
  – Their two unfortunate legacies
    • Poor EMF measurements
    • Outcome inefficient to study
Current Prevailing Perceptions about EMF Health Effect

• Misconceptions – no association:
  – Poor measurement for EMF, though evolved:
    • Wire codes
    • Interviews
    • Distance from power lines or power stations
    • Spot measurements
    • Personal EMF measurement (carrying a meter)
    • Inability to measure EMF exposure: no association
  
• Bottom Line: You need to measure EMF correctly and accurately before claiming that there is no association.
Current Prevailing Perceptions about EMF Health Effect

• *Insensitive* outcomes to study
  • Cancer
    – Long latency period: 20-25 years from exposure to diagnosis
    – Rare outcomes needing *Retrospective* ascertainment of EMF exposure (bad combination)

• Bottom line: Need to focus on sensitive endpoints first
Current Prevailing Perceptions about EMF Health Effect

• Power line EMF and Cell phone EMF have different health effect
  • Both are EMF
  • Only difference is frequency: low vs. high

• Energy level
  • Heat injury (thermal effect), not the main concern
  • Non-thermal effect largely unknown and the main concerns (miscarriage, cancer, autoimmune diseases, obesity, etc.)
Why EMF exposure?

- Significant increase in last 30 years
  - Build out of wireless network 5G now
  - Wireless devices (e.g., cell phones)
  - Emerging evidence of adverse effects
    - Miscarriage
    - Blood glucose level
    - Childhood asthma
    - Childhood obesity
    - Childhood neurodevelopment disorders
    - Childhood abnormal thyroid condition
    - Poor sperm quality
Our Latest Studies

• A prospective cohort study
• Exposure measured in pregnancy
• Outcome followed
  – Miscarriage in pregnancy
  – Childhood conditions (*no time to discuss today*)
    • Asthma
    • Obesity
    • ADHD
    • Abnormal thyroid condition
Study Population & Recruitment

• Kaiser Permanente Northern California (KPNC) members in the San Francisco area
• All pregnant women
• Recruited in the 1\textsuperscript{st} or 2\textsuperscript{nd} trimester
• In-person interview
Exposure Measurement

• All participants wore a meter for 24 hours in pregnancy (1\textsuperscript{st} or 2\textsuperscript{nd} trimester)
• Diary of activities
• Assessment of representativeness of measurement day: a \textit{typical day} in pregnancy
Findings on *In-utero* EMF Exposure

- Exposure to high level of MF non-ionizing radiation during pregnancy is associated with an increased risk of:
  - Miscarriage (RR=2.7)
  - Asthma in offspring (RR=2.5)
  - Obesity in offspring (RR=5.0)
  - ADHD (RR=2.9)
  - Abnormal thyroid function (RR=3.1)

- Dose-response relationship (long-term effects)
- Stronger when measured on a typical day
Table 1. Daily Magnetic Field Exposure during Pregnancy and the Risk of Miscarriage

<table>
<thead>
<tr>
<th>MF 99&lt;sup&gt;th&lt;/sup&gt; Percentile</th>
<th>Total N</th>
<th>N with miscarriage (%)</th>
<th>aHR&lt;sup&gt;a&lt;/sup&gt; (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2.5mg</td>
<td>219</td>
<td>36 (16.4%)</td>
<td>Ref</td>
</tr>
<tr>
<td>≥2.5mg</td>
<td>694</td>
<td>164 (23.6%)</td>
<td>1.48 (1.03-2.14)</td>
</tr>
<tr>
<td><strong>Typical day</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2.5mg</td>
<td>106</td>
<td>11 (10.4%)</td>
<td>Ref</td>
</tr>
<tr>
<td>≥2.5mg</td>
<td>347</td>
<td>84 (24.2%)</td>
<td>2.72 (1.42-5.19)</td>
</tr>
<tr>
<td><strong>Non-typical day</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2.5mg</td>
<td>113</td>
<td>25 (22.1%)</td>
<td>Ref</td>
</tr>
<tr>
<td>≥2.5mg</td>
<td>347</td>
<td>80 (23.1%)</td>
<td>1.08 (0.67-1.73)</td>
</tr>
</tbody>
</table>

aHR: Adjusted Hazard Ratio.

<sup>a</sup>Adjusted for maternal age at interview, race, education, smoking since LMP and prior miscarriage.
### Table 4. Daily Magnetic Field Exposure during Pregnancy and the Risk of Miscarriage – Dose-Response, on typical day only

<table>
<thead>
<tr>
<th>MF 99&lt;sup&gt;th&lt;/sup&gt; Percentile</th>
<th>Total N</th>
<th>N with miscarriage (%)</th>
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<td>&lt;2.5mg</td>
<td>106</td>
<td>11 (11.4%)</td>
<td>ref</td>
</tr>
<tr>
<td>2.5mg-5.0mg</td>
<td>195</td>
<td>53 (27.2%)</td>
<td>3.11 (1.58-6.13)</td>
</tr>
<tr>
<td>≥5.0mg</td>
<td>152</td>
<td>31 (20.4%)</td>
<td>2.29 (1.13-4.64)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Adjusted Hazard Ratio.

<sup>a</sup>Adjusted for maternal age at interview, race, education, smoking since LMP, and prior miscarriage.

<sup>b</sup>Adjusted for maternal age at interview, race, education, smoking since LMP, and gravidity.
Figure 1. Kaplan-Meier Estimates of Asthma Risk by Maternal Magnetic Field (MF) Exposure Level during Pregnancy

- Low MF Level
- Medium MF Level
- High MF Level

Percent of Remaining Asthma Free vs. Age (Years)
DISCUSSION

• Need a better measurement of EMF to see any effect even with personal measurements

• Potential Mechanisms:
  – Epigenetics
  – Known effect:
    • Cell-cell communication
    • Cell activities: metabolism (JAMA publication)
LIMITATIONS

• No measurement throughout pregnancy
  – For childhood outcomes
  – Non-differential misclassification

• No measurement after birth
  – Non-differential misclassification
STRENGTHS

• Prospective study design
  – Reduce participation bias

• Objective measurement both exposure (MF level) and outcome (asthma)
  – Reduce recall bias or errors

• Synergistic effect with known risk factors for asthma
CONCLUSION

• Exposure to high level of MF non-ionizing radiation during pregnancy is associated with
  – an increased risk of miscarriage (immediate effect)
  – Likely a threshold effect, thus, no apparent dose-response relationship
CONCLUSION

• Exposure to high level of MF non-ionizing radiation during pregnancy is associated with long-term adverse impacts on offspring
  – Childhood asthma
  – Childhood obesity
  – Neurodevelopmental disorders like ADHD
  – Abnormal thyroid condition

• Does-response relationship