RADIOFREQUENCY ELECTROMAGNETIC FIELDS:
WHAT WE KNOW AND WHAT ARE THE POSSIBLE IMPACTS ON HEALTH

Dr. Simona Panzacchi
Cesare Maltoni
Cancer Reaserch Center
The Ramazzini Institute (RI) is a non-profit social cooperative.

The mission of the RI is focused on primary and secondary prevention of environmental and occupational diseases, through independent scientific research, clinical activities and dissemination of information.

The RI is supported by over 34,000 members.
“It is much better to prevent than to cure”.
De Morbis Artificum Diatriba 1700
Cesare Maltoni
Cancer Research Center
CMCRC

Castle built in 1475
Domus Jucunditatis
Bentivoglio family
CARCINOGENICITY BIOASSAYS

With over 200 compounds studied, it is the largest carcinogenicity bioassays program in Europe, second in the world after the US National Toxicology Program.

- Compounds/agents tested: 210
- Overall carcinogenicity results:
  - Clear evidence: (46%)
  - Equivocal evidence: (15%)
  - No evidence: (39%)

## RI: CARCINOGENICITY BIOASSAYS

<table>
<thead>
<tr>
<th>Agent</th>
<th>CMCRC-RI*</th>
<th>IARC Group/year</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl Chloride</td>
<td>1974</td>
<td>1/1979</td>
<td>5 years</td>
</tr>
<tr>
<td>Chromium (VI) Compounds</td>
<td>1974</td>
<td>1/2012</td>
<td>38 years</td>
</tr>
<tr>
<td>Benzene</td>
<td>1979</td>
<td>1/2012</td>
<td>33 years</td>
</tr>
<tr>
<td>Erionite</td>
<td>1982</td>
<td>1/2012</td>
<td>30 years</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>1986</td>
<td>1/2014</td>
<td>28 years</td>
</tr>
</tbody>
</table>

*first evidence as experimental multipotent carcinogen
### RI: Carcinogenicity Bioassays

<table>
<thead>
<tr>
<th>Agent</th>
<th>CMCRC-RI*</th>
<th>IARC Group/year</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styrene-7,8-oxide</td>
<td>1988</td>
<td>2A/1994</td>
<td>6 years</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>1988</td>
<td>2A/2016</td>
<td>28 years</td>
</tr>
<tr>
<td>Silica dust</td>
<td>1988</td>
<td>1/2012</td>
<td>24 years</td>
</tr>
<tr>
<td>Asbestos (all forms)</td>
<td>1989</td>
<td>1/2012</td>
<td>23 years</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>1989</td>
<td>1/2012</td>
<td>23 years</td>
</tr>
</tbody>
</table>

*first evidence as experimental multipotent carcinogen
<table>
<thead>
<tr>
<th>Agent</th>
<th>CMCRC-RI*</th>
<th>IARC Group/year</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tamoxifen</td>
<td>1997</td>
<td>1/2012</td>
<td>15 years</td>
</tr>
<tr>
<td>Diesel (engine exhaust)</td>
<td>1997</td>
<td>1/2013</td>
<td>16 years</td>
</tr>
<tr>
<td>Ethanol (alcoholic beverages)</td>
<td>2002</td>
<td>1/2012</td>
<td>10 years</td>
</tr>
<tr>
<td>Acetaldehyde (alcoholic beverages)</td>
<td>2002</td>
<td>1/2012</td>
<td>10 years</td>
</tr>
<tr>
<td>Fluoro-edenite</td>
<td>2004</td>
<td>1/2017</td>
<td>13 years</td>
</tr>
</tbody>
</table>

*first evidence as experimental multipotent carcinogen*
RADIOFREQUENCY ELECTROMAGNETIC FIELDS (RF EMF)
Radiation exists across a spectrum from very low-energy (low-frequency) radiation to very high-energy (high-frequency) radiation.

**Ionizing radiation**: enough energy to remove an electron from (ionize) an atom.

**Non-ionizing radiation**: not have enough energy to remove electrons from an atom.
EXPOSURE

- Work environments (heat inductors; radar)
- Radio base stations of mobile telephony
- Radio-telephone transmitting antennas
- Mobile telephony (cell phones, tablets, cordless...)
**Exposure limits for radio-frequency fields (public)**

**Data by country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Electric field (V/m)</th>
<th>Power density (W/m²)</th>
<th>Specific absorption rate (SAR) (W/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>900 MHz</td>
<td>1800 MHz</td>
<td>900 MHz</td>
</tr>
<tr>
<td>France</td>
<td>2017</td>
<td>41</td>
<td>58</td>
<td>4.5</td>
</tr>
<tr>
<td>Germany</td>
<td>2017</td>
<td>41.25</td>
<td>58</td>
<td>4.5</td>
</tr>
<tr>
<td>Italy</td>
<td>2017</td>
<td>620</td>
<td>620</td>
<td>0.1/1.0</td>
</tr>
<tr>
<td>United States of America</td>
<td>2017</td>
<td>47.6</td>
<td>61.4</td>
<td>6</td>
</tr>
</tbody>
</table>

---

1. The table includes exposure limit data for different countries for the years 2017.
2. The data includes measurements for electric field (V/m) and power density (W/m²) at 900 MHz and 1800 MHz.
3. The specific absorption rate (SAR) is given in W/kg for the whole body, head and trunk, and limbs.
4. The data is sourced from the Global Health Observatory data repository.
Electrosmog is the pollution derived from electromagnetic radiation, which spreads in the air, but which we can neither hear nor see.

It is an imperceptible form of pollution.
Exposure to very high RF intensities can result in heating of biological tissue and an increase in body temperature.

In children, due to the size and composition of the tissues, the whole brain overheats.

In particular brain tumors and vestibular schwannomas are associated with the massive use of the mobile phone (Hardell et al. 2011: Interphone study group 2010). “limited” epidemiological evidence”
Advisory Group recommendations on priorities for the IARC Monographs

An Advisory Group of 29 scientists from 18 countries met in March 2019, to recommend priorities for the International Agency for Research on Cancer (IARC) Monographs programme during 2020–24. IARC periodically convenes such advisory groups to ensure that the Monographs evaluations reflect the current state of scientific evidence relevant to carcinogenicity. A detailed report of the Advisory Group will be published subsequently.

The Advisory Group assessed the response to a public call for nominations and considered more than 170 unique candidate agents, including the recommended priorities remaining from a similar Advisory Group meeting convened in 2014. The expertise of the Advisory Group covered multiple disciplines, and the members appraised, on an individual nomination basis, the evidence according to human exposure (including any evidence of exposure in low-income and medium-income countries), cancer epidemiology, cancer bioassays in experimental animals, and carcogenic mechanisms, in line with the evaluation methodology recently refined in the Preamble to the IARC Monographs. A complementary approach assessed all nominations using a cheminformatics, text mining, and chemical similarity analysis workflow, this approach helped to reveal coverage and gaps in the extent of evidence across data streams, supporting decisions on individual agents and groups of chemically related nominations. The Advisory Group deliberated on all nominated agents both by evidence stream (i.e., exposure, human cancer, cancer bioassay, and carcogenic mechanisms) and by type of agent (e.g., metals, fibres, chemicals, biological agents, and complex mixtures) to inform development of priority recommendations.

The Advisory Group recommended a broad range of agents with high (table 1), medium, or low (table 2) priority for evaluation. Priority was assigned on the basis of evidence:

<table>
<thead>
<tr>
<th>Agents previously evaluated by IARC Monographs?</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>New human cancer, bioassay, and mechanistic evidence to warrant re-evaluation of the classification</td>
<td>- Acrylonitrile, acrylonitrile butadiene rubber, carbon tetrachloride, methacrylate, non-ionizing radiation (radiofrequency), some perfluorinated compounds (e.g., perfluorooctanoic acid)</td>
</tr>
</tbody>
</table>
EXPERIMENTAL PROJECT ON NON-IONIZING RADIATIONS: RADIOFREQUENCY RADIATION
All experiments started at the 12° day of pregnancy and continued life-span

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Number of animals (M+F)</th>
<th>Treatment</th>
<th>State of the art *</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT 1 CEMRF</td>
<td>2,448</td>
<td>RFR 1.8 GHz</td>
<td>Published (partially)</td>
</tr>
<tr>
<td>BT 3 CEMRF</td>
<td>617</td>
<td>RFR/MW 1.8 GHz + γ-radiation (0.1 Gy)</td>
<td>Ongoing</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,065</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* STATE OF THE ART:
- **RFR/MW alone**: all tissues embedded, brain and heart results published. Pathological evaluation of other organs is currently ongoing
- **RFR/MW +γ radiation**: all tissues embedded, all slides to be prepared
RADIO FREQUENCIES IN VIVO STUDIES

GSM (Global System for Mobile Communication) & CDMA (Code Division Multiple Access)
Study on rats and mice (1.9 e 0.9 GHz)

≈ Near field

GSM (Global System for Mobile Communication)
Study on rats (1.8GHz)

Far field
RADIO FREQUENCIES IN VIVO STUDIES

The SAR represents the amount of energy that is absorbed in human tissues following interaction with the electromagnetic field.
Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission


Cisare McGuiri Cancer Research Center, Ramazzini Institute, Castello di Bietola, via Saliceto 3, Bietola, 40010 Bologna, Italy

NTP TECHNICAL REPORT
ON THE
TOXICOLOGY AND CARCINOGENESIS STUDIES IN Hsd:SPRAGUE DAWLEY SD RATS EXPOSED TO WHOLE-BODY RADIO FREQUENCY RADIATION AT A FREQUENCY (900 MHZ) AND MODULATIONS (GSM AND CDMA) USED BY CELL PHONES

NATIONAL TOXICOLOGY PROGRAM
P.O. Box 12233
Research Triangle Park, NC 27709

November 2018
RADIO FREQUENCIES IN VIVO STUDIES: RESULTS

• **Brain**
  Statistically significant increase in **malignant gliomas**. Increase in *glial cell hyperplasia* in exposed male and female rats.

• **Heart**
  Statistically significant positive trend in **malignant Schwannoma**. Increase in *Schwann cell hyperplasia* in exposed male and female rats.

• **Adrenal glands**
  Increased incidence of pheochromocytomas of the adrenal medulla in male rats.

• **Brain**
  Slight non-statistically significant dose-related increase in **malignant glioma** in exposed female rats.

• **Heart**
  Statistically significant increase in **malignant Schwannoma** in males at the highest dose). Increase in *Schwann cell hyperplasia* in exposed male and female rats.
RFR exposure was linked to DNA damage in:

• the frontal cortex of the brain in male mice
• the blood cells of female mice, and
• the hippocampus of male rats.
We examined rat gliomas using next generation sequencing panel of 23 human glioma-related genes to understand the translational relevance of these tumors to human health.

Data suggest that rat gliomas histologically resemble low grade human gliomas but the genetic alterations are similar to more aggressive in people.
CONCLUSIONS

➢ Both the NTP and RI studies found statistically significant increases in the development of the same type of very rare glial malignancies of the heart in treated male rats and of the brain in females.

➢ The tumors observed by NTP and RI (Schwannomas) are of the same histotype as those observed in excess in epidemiological studies.

➢ Both NTP and RI showed a low but statistically significant risk at different doses.
In light of this evidence, the National Toxicology Program recently evaluated the evidence for the carcinogenicity of radio frequency magnetic fields produced by mobile phones as "clear evidence."

“However, the studies question the long-held assumption that RFR is of no concern as long as the energy level is low and does not significantly heat the tissues.”