Environmental Causes of Cancer

Dick Clapp
BUSPH and U. Mass. - Lowell
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International Agency for Research on Cancer (IARC)

Evaluations of agents, mixtures, and exposures (as of July 2004)

Total agents evaluated 900

- Carcinogenic to humans 95
- Probably carcinogenic to humans 66
- Possibly carcinogenic to humans 241
- Not classifiable 497
- Probably not carcinogenic to humans 1

"Could you hurry and find a cure for cancer? THAT WOULD BE SO MUCH EASIER THAN PREVENTION!"
Substances and mixtures evaluated by IARC as definite human carcinogens and that are occupational exposures.

<table>
<thead>
<tr>
<th>Substance or mixture</th>
<th>Occupation or industry in which the substance is found</th>
<th>Site(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical agents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionizing radiation and sources thereof, including, notably, X rays, γ rays, neutrons, and radon gas</td>
<td>Radiologists; technologists; nuclear workers; radium-dial painters; underground miners; plutonium workers; cleanup workers following nuclear accidents; aircraft crew</td>
<td>Bone&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leukemia&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td></td>
<td></td>
<td>Lung&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td></td>
<td></td>
<td>Liver&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thyroid&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Others&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melanoma&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skin&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Solar radiation</td>
<td>Outdoor workers</td>
<td></td>
</tr>
<tr>
<td>Respirable dusts and fibers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asbestos</td>
<td>Mining and milling; by-product manufacture; insulating; shipyard workers; sheet-metal workers; asbestos cement industry</td>
<td>Lung&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesothelioma&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Larynx&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GI tract&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Erionite</td>
<td>Waste treatment; sewage; agricultural waste; air pollution control systems; cement aggregates; building materials</td>
<td>Mesothelioma&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Silica, crystalline</td>
<td>Granite and stone industries; ceramics, glass, and related industries; foundries and metallurgical industries; abrasives; construction; farming</td>
<td>Lung&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Talc containing asbestiform fibers</td>
<td>Manufacture of pottery, paper, paint, and cosmetics</td>
<td>Lung&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wood dust</td>
<td>Logging and sawmill workers; pulp and paper and paperboard industry; woodworking trades (e.g., furniture industries, cabinetmaking, carpentry and construction); used as filler in plastic and linoleum production</td>
<td>Lung&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mesothelioma&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nasal cavities and paranasal sinuses&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Substances and mixtures evaluated by IARC as definite human carcinogens and that are occupational exposures, cont’d.

<table>
<thead>
<tr>
<th>Category</th>
<th>Exposure/Manufacture</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic and arsenic compounds</td>
<td>Beryllium extraction and processing; aircraft and aerospace industries; electronics and nuclear industries; jewelers</td>
<td></td>
</tr>
<tr>
<td>Beryllium</td>
<td>Cadmium-smelter workers; battery production workers; cadmium-copper alloy workers; dyes and pigments production; electroplating processes</td>
<td></td>
</tr>
<tr>
<td>Cadmium and cadmium compounds</td>
<td>Chromium production plants; dyes and pigments; plating and engraving; chromium ferro-alloy production; stainless-steel welding; in wood preservatives; leather tanning; water treatment; inks; photography; lithography; drilling muds; synthetic perfumes; pyrotechnics; corrosion resistance</td>
<td></td>
</tr>
<tr>
<td>Chromium compounds, hexavalent</td>
<td>Nickel refining and smelting; welding</td>
<td></td>
</tr>
<tr>
<td>Selected nickel compounds, including combinations of nickel oxides and sulfides in the nickel refining industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood and fossil fuels and their by-products</td>
<td>Production; solvents in the shoe production industry; chemical, pharmaceutical, and rubber industries; printing industry (rotogravure plants, bindery departments); gasoline additive</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>Production of refined chemicals and coal tar products (patent-fuel); coke production; coal gasification; aluminum production; foundries; road paving and construction (roofers and slaters)</td>
<td></td>
</tr>
<tr>
<td>Coal tars and pitches</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Childhood Brain Cancer: Documented Links

- Ionizing radiation [Strong]
- dichlorvos [Good]
- lindane [Good]
- Pesticides [Good]
- Second-hand smoke [Good]
- Solvents [Good]

Melanoma: Documented Links

- UV radiation [Strong]

Thyroid Cancer: Documented Links

- Ionizing radiation [Strong]
- ethylene thiourea (ETU) [Good]

Bone Cancer: Documented Links

• radium [Strong]
• Pesticides [Good]

Brain Cancer: Documented Links

• Ionizing radiation [Strong]
• Chromium [Good]
• methylene chloride [Good]

Colo-rectal Cancer: Documented Links

- 1,1-dichloroethane [Good]
- alachlor [Good]
- Aromatic amines [Good]
- Chlorination by-products [Good]
- Ionizing radiation [Good]
- Solvents [Good]

Prostate Cancer: Documented Links

• Agent Orange [Good]
• Aromatic amines [Good]
• methyl bromide [Good]
• Organochlorine pesticides [Good]
• PAHs [Good]
• Pesticides [Good]
• Solvents [Good]

Childhood Leukemias: Documented Links

- benzene [Strong]
- Ionizing radiation [Strong]
- Agent Orange [Good]
- carbon tetrachloride [Good]
- Chlorinated solvents [Good]
- Metal dusts [Good]
- Pesticides [Good]
- Secondhand smoke [Good]
- trichloroethylene (TCE) [Good]

Liver Cancer: Documented Links

- aflatoxin B1 (Aflatoxins) [Strong]
- Androgens [Strong]
- ethyl alcohol (ethanol) [Strong]
- Hydrocarbons [Strong]
- N-nitrosodimethylamine [Strong]
- arsenic [Good]
- captafol [Good]
- PCBs [Good]
- thorium dioxide (Thorostat) [Good]
- trichloroethylene (TCE) [Good]
- vinyl chloride [Good]

IARC: Examples of agents classified as human carcinogens (not necessarily found in occupational settings)

- **Alcohol** - in alcoholic drinks
- **Arsenic** - in drinking water, wood preservatives, pesticides
- **Benzene** - in vehicle exhaust, cigarette smoke, and some detergents, drugs, dyes, pesticides, plastics, etc.
- **Cadmium** - as a stabilizer in PVC products, in re-chargeable batteries & phosphate fertilizers
- **Dioxin** - production or combustion of chlorinated dyes, herbicides, some drugs & wood preservatives
- **Formaldehyde** - in resins in common household materials and products
- **Oestrogen therapy** - hormone replacement therapy
- **Oral contraceptives** - birth control pills
- **Radiation** - (ionizing) in radioactive material, high-voltage equipment, nuclear reactions, stars
- **Tamoxifen** - breast cancer treatment
- **Vinyl chloride** - in polyvinyl resins
Breast Cancer: Documented Links

- Active smoking [Strong]
- Estrogens/DES [Strong]
- ethyl alcohol (ethanol) [Strong]
- Ionizing radiation [Strong]
- Secondhand smoke [Strong]
- Aromatic amines [Good]
- B-naphthylamine [Good]
- benzidine [Good]
- ethylene oxide [Good]
- PAHs [Good]
- PCBs [Good]
- Progestins [Good]
- Solvents [Good]
- tetrachloroethylene (PCE) [Good]

Non-Hodgkin’s Lymphoma: Documented Links

- 1,3-butadiene [Strong]
- benzene [Strong]
- Dioxins/TCDD [Strong]
- 2,4-D [Good]
- Agent Orange [Good]
- aldrin [Good]
- Aromatic amines [Good]
- captan [Good]
- Carbamates [Good]
- carbaryl [Good]
- carbon disulfide [Good]
- carbon tetrachloride [Good]
- Chlorophenols [Good]
- Creosotes [Good]
- DDT/DDE [Good]
- dicamba [Good]
- dichlorvos [Good]
- Fungicides [Good]
- Insecticides [Good]
- Ionizing radiation [Good]
- lindane [Good]
- malathion [Good]
- MCPA [Good]
- mecoprop [Good]
- Organochlorine pesticides [Good]
- Organophosphates [Good]
- PCBs [Good]
- Pesticides [Good]
- Phenoxyacetic herbicides [Good]
- Secondhand smoke [Good]
- Solvents [Good]
- tetrachloroethylene (PCE) [Good]
- trichloroethylene (TCE) [Good]

### Table 20.—Proportions of cancer deaths attributed to various different factors

<table>
<thead>
<tr>
<th>Text section No.</th>
<th>Factor or class of factors</th>
<th>Percent of all cancer deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Tobacco</td>
<td>30</td>
</tr>
<tr>
<td>5.2</td>
<td>Alcohol</td>
<td>3</td>
</tr>
<tr>
<td>5.3</td>
<td>Diet</td>
<td>35</td>
</tr>
<tr>
<td>5.4</td>
<td>Food additives</td>
<td>&lt;1</td>
</tr>
<tr>
<td>5.5</td>
<td>Reproductive&lt;sup&gt;b&lt;/sup&gt; and sexual behaviour</td>
<td>7</td>
</tr>
<tr>
<td>5.6</td>
<td>Occupation</td>
<td>4</td>
</tr>
<tr>
<td>5.7</td>
<td>Pollution</td>
<td>2</td>
</tr>
<tr>
<td>5.8</td>
<td>Industrial products</td>
<td>&lt;1</td>
</tr>
<tr>
<td>5.9</td>
<td>Medicines and medical procedures</td>
<td>1</td>
</tr>
<tr>
<td>5.10</td>
<td>Geophysical factors&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>5.11</td>
<td>Infection</td>
<td>10&lt;sup&gt;?&lt;/sup&gt;</td>
</tr>
<tr>
<td>5.12</td>
<td>Unknown</td>
<td>?</td>
</tr>
</tbody>
</table>

Notable Limitations:

- Relied on epi studies of workers in large industries.
- Did not consider exposures in smaller work places.
- Did not consider exposures from indirect contact with carcinogens.
- Excluded deaths of people 65 and over!

Acknowledged:

- Some exposures interact with each other.
- Sum of causes could only be more than 100%.
- Proportions are impossible to estimate because all avoidable causes are unknown.

Stated purpose:

- To make sense of “public confusion about cancer prevention…”

“…the public can become overly concerned about minimal risks while losing sight of major cancer risk factors that can be controlled or modified, in particular, tobacco use, diet, exercise, and sun exposure.”

“…supported by the generous contributions of Margorie G. and Vincent L. Gregory Jr.”

When CEO of Rohm & Haas, Gregory described additional worker fatalities due to respiratory cancer from BCME exposure at a Pennsylvania plant as “inevitable.”

A Few Lessons from History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1775</td>
<td>Scrotal cancer in small boys linked to their work assisting chimney sweeps. (PAHs)</td>
</tr>
<tr>
<td>1800’s</td>
<td>Pipe smoking recognized as a cause of cancer of the lip.</td>
</tr>
<tr>
<td>1903-06</td>
<td>First reports of cancers caused by X-ray exposure.</td>
</tr>
<tr>
<td>1915</td>
<td>Smoking linked to cancer of the mouth.</td>
</tr>
<tr>
<td>1920’s</td>
<td>Smoking linked to lung cancer.</td>
</tr>
</tbody>
</table>

A Few Lessons from History

Early 1900’s  Bone, nasal, & stomach cancers linked to women and girls who were radium dial painters. (Radiation)

1936, 1938  First documentations of asbestos and lung cancer link.

1946  Radiologists found 8x more likely to die of leukemia than other doctors.

### A Few Lessons from History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>Scrotal cancer in men linked to work with cutting oils.</td>
</tr>
<tr>
<td>1950s</td>
<td>Lung cancer in excess among uranium ore miners of the Colorado Plateau.</td>
</tr>
<tr>
<td>1970’s</td>
<td>20,000 children irradiated for ringworm treatment had 6x the risk of developing cancers (higher for brain &amp; leukemia).</td>
</tr>
</tbody>
</table>

# A Few Lessons from History

**Tom’s River, NJ**

<table>
<thead>
<tr>
<th>Trichloroethylene</th>
<th>Radium</th>
</tr>
</thead>
<tbody>
<tr>
<td>In drinking water from early 1980s to 1990s; parents noticed increased childhood cancer in support group called “Ocean of Love.” Dumping of chemicals in landfill suspected.</td>
<td></td>
</tr>
</tbody>
</table>

*Studies found statistical link between exposure (especially prenatal exposure) to contaminated drinking water and risk of leukemia*

Recent studies:

- Ionizing radiation linked to cancers of the bladder, bone, brain, breast, colon, liver, lung, ovary, rectum, salivary gland, skin, stomach, and thyroid, as well as leukemia, mesothelioma, multiple myeloma, non-Hodgkin’s lymphoma, and sarcomas.

- Smoking has been linked to cancers of the bladder, breast, cervix, kidney, larynx, lung, mouth, nasopharynx, oesophagus, pancreas, and adult on-set leukemia.

- Asbestos exposure linked to cancers of the kidney, larynx, lung, and stomach and to mesothelioma.

Elevated cancer rates are found:
  • In farming states
  • In areas of pesticide use
  • Near hazardous waste sites and incinerators
  • Downwind of certain industrial activities
  • Near certain drinking-water wells
  • In cities
  • Among workers exposed to toxins
  • Among children whose parents work with toxins.
  • Associated with other sources of pollution.

Trends in cancer incidence rates in “developed” countries.

A Few Lessons from History

- Immigrants acquire the cancer rates of their new country within 1-2 generations.
- Among twins, environmental exposures unique to those with breast cancer made the most significant contribution to the development of the disease.

A Few Lessons from History

Good news!

- A ban on 2 pesticides linked to NHL led to a subsequent reduction in NHL rates in Sweden and other countries.
- Decreased air pollution leads to fewer deaths from lung cancer and other diseases.
- Australia’s successful “Slip, Slop, Slap” campaign against skin cancer.
  → The sun has no stockholders!

A Few Lessons from History

Slip, Slop, Slap!
It sounds like a breeze when you say it like that
Slip, Slop, Slap!
In the sun we always say "Slip Slop Slap!"
Slip, Slop, Slap!
Slip on a shirt, slop on sunscreen and slap on a hat,
Slip, Slop, Slap!
You can stop skin cancer - say: "Slip, Slop, Slap!"

A Few Lessons from History

“Environmental carcinogenesis is the newest and one of the most ominous of the endproducts of our industrial environment. Though its full scope and extent are still unknown..., enough is known to make it obvious that extrinsic carcinogens present a very immediate and pressing problem in public and individual health.”

-- Wilhelm Hueper, senior scientist
U.S. National Cancer Institute
Environmental Cancer, 1948
“Future historians may well be amazed by our distorted sense of proportion. How could intelligent beings seek to control a few unwanted species by a method that contaminated the entire environment and brought the threat of disease and death even to their own kind? Yet this is precisely what we have done.”

-- Rachel Carson, *Silent Spring*, 1962
The Precautionary Principle

• Indication of harm, not proof of harm, is a call to act.

• The proponent of an activity, rather than the public, should bear the burden of proof.

• Decision-making must be open, informed and democratic and must include potentially affected parties.

• Decision-making must also involve an examination of the full range of alternatives, including no action.

-- from the Wingspread Statement, 1998
"If the lessons from the tobacco control experience are applied in other areas, even greater gains can be made in cancer prevention."

-- Canadian Cancer Statistics 2005
The Need to Act on What We Know

“It is time to start pursuing alternative paths. From the right to know and the duty to inquire flows the obligation to act.”

-- Sandra Steingraber
Living Downstream, 1997
There is no scientific solution to a social problem.

-- Judith Brady, Cancer activist
San Francisco, 2006
Environmental and Occupational Causes of Cancer
A Review of Recent Scientific Literature

Richard W. Clapp, D.Sc.
Genevieve K. Howe, MPH
Molly M. Jacobs, MPH

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