What are Chemicals?

Everything in your life except light, radiation and sound waves.

Chemicals are plants, food, cars, other living things
Rachel Carson  1962
Clean Water Act  1972
Clean Air Act  1970
Resource Conservation & Recovery Act  1976
Toxic Substances Control Act  1976
Comprehensive Environmental Response, Compensation and Liability Act CERCLA
(Superfund) 1980

Worker Right to Know 1986

Superfund Amendments and Reauthorization Act (SARA) 1986
Chemical-Induced Effects

- Acute- mucous membrane irritation, drowsiness-immediate/transient
- Delayed-hepatotoxicity- 48/72 hours
- Chronic toxicity-cirrhosis of the liver
- Carcinogenicity-hepatocarcinoma
Chemical-Induced Effects (cont.)

- Mutagenicity - germ cells/somatic cells
- Teratogenicity - birth defects
- Organ toxicity:
  - Neurotoxicity
  - Hepatotoxicity
As Stated by Admiral Crowe:

The Hallmark of an educated person is the ability, when facts warrant to change one’s mind.

Admiral William Crowe

• Retired Chairman of the Joint Chiefs of Staff
The number of storks in Europe has been decreasing for decades. At the same time, the European birth rate has also been decreasing. We would be foolish to accept this high correlation as evidence that storks bring babies.
# Doses of Common Substances

<table>
<thead>
<tr>
<th>Substance</th>
<th>Normal/Unharmful Dose</th>
<th>Lethal Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td>1.5 Quarts</td>
<td>15 Quarts</td>
</tr>
<tr>
<td><strong>Aspirin</strong></td>
<td>2 Tablets</td>
<td>90 Tablets</td>
</tr>
<tr>
<td><strong>Beer</strong></td>
<td>1 Beer (15 mg/dl or 0.015%)</td>
<td>33 Beers (500 mg/dl or 0.5%)</td>
</tr>
<tr>
<td><strong>Salt</strong></td>
<td>3 Level Teaspoons</td>
<td>60 Level Teaspoons</td>
</tr>
<tr>
<td><strong>Lima Beans (Cyanide)</strong></td>
<td>0.036-1.18 mg/day (eating lima beans)</td>
<td>106 mg</td>
</tr>
</tbody>
</table>
Example of a Dose-Response Curve
What concentration of chemicals in air, water, soil, food, consumer products are safe?

Chemicals produce specific effects and these are dose related.
Risk = Toxicity x Exposure

where

T = toxicity of a specific chemical

E = amount of exposure a population has to a specified chemical
Problem Statement

Acceptable risk levels
Public alarmist reaction to any risk
Placing risk in perspective
Types of Risk Assessments

Linear: Used to portray the risk of carcinogenicity

Threshold: Used to model all other forms of toxicity
## Actual Toxicity and Ranking

<table>
<thead>
<tr>
<th>Agents</th>
<th>LD$_{50}$</th>
<th>Expected Human Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCBs</td>
<td>14,000</td>
<td>1 Quart</td>
</tr>
<tr>
<td>Alcohol</td>
<td>10,000</td>
<td>1 Pint-1 Quart</td>
</tr>
<tr>
<td>Table salt</td>
<td>4,000</td>
<td>1 Pint</td>
</tr>
<tr>
<td>Iron</td>
<td>1,500</td>
<td>1 Ounce-1 Pint</td>
</tr>
<tr>
<td>DDT</td>
<td>100</td>
<td>1 Teaspoon-1 Ounce</td>
</tr>
<tr>
<td>Strychnine</td>
<td>2</td>
<td>4 Drops</td>
</tr>
<tr>
<td>Nicotine</td>
<td>1</td>
<td>1 Drop</td>
</tr>
<tr>
<td>TCDD</td>
<td>0.001</td>
<td>Less Than 1 Drop</td>
</tr>
<tr>
<td>Botulinus toxin</td>
<td>0.00001</td>
<td>Less Than 1 Drop</td>
</tr>
<tr>
<td>Teratogenicity</td>
<td>Mutagenicity</td>
<td>Carcinogenicity</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>1. Insidious Nature (Cause is Mild Relative to the Effect)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Duration and Time Between Cause and Effect</td>
<td>Weeks</td>
<td>Generations</td>
</tr>
<tr>
<td>3. Irreversible</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Greater Susceptibility of Immature Tissues</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. Differences</td>
<td>Altered Development at Tissue/Organ Level</td>
<td>Altered Nucleotide Sequence-Molecular Level: DNA</td>
</tr>
</tbody>
</table>
Hazard Identification-

What adverse health effects can the chemical produce?
Hazard Evaluation - what are the dose response relationships for the adverse health effects?
Sources of Toxicity Information

Material Safety Data Sheets (MSDS)
Integrated Risk Information System (IRIS)
Hazardous Substances Database (HSDB)
Arsenic trioxide MSDS

Route of entry

- inhalation: yes
- skin: yes
- ingestion: yes

Carcinogenicity

- NTP: yes
- IARC: yes
- OSHA: yes

Symptoms may include chest pain, dyspnea, pulmonary edema, cyanosis, giddiness, restlessness, lassitude, headache, hypotension
Arsenic trioxide MSDS

Emergency/First Aid Procedure

- inhalation: remove to fresh air, artificial respiration or oxygen
- skin: may cause itching, burning, sensitization
- ingestion: lethal dose is 120 mg
Chloroform MSDS

Route of entry
- inhalation: yes
- skin: yes
- ingestion: yes
- exposure may cause burns, nausea, headache, dizziness, vomiting, severe inflammation, swelling, disorientation

Carcinogenicity
- NTP: no
- IARC: yes
- OSHA: no
Chloroform MSDS

Emergency/First Aid Procedure

? inhalation: remove to fresh air, artificial respiration or oxygen

? skin: flush with water 15-20 min.

? ingestion: induce vomiting
An Example of Dose and Response

**DOSE**
Number of 325 mg ASPIRIN tablets

**RESPONSE**
- Reduce risk of heart attacks
- Relief of headaches, minor aches & pains
- Relief of arthritis and rheumatoid condition
- Treatment of acute rheumatic fever
- Adult lethal dose
Risk Assessment

--is the process used to determine if there is excess risk, above that allowed by public policy
The four basic components of risk assessment include:

- Hazard Identification
- Hazard Evaluation
- Exposure Evaluation
- Risk Estimation
Risk = Toxicity $\times$ Exposure

where

$T =$ toxicity of a specific chemical

$E =$ amount of exposure a population has to a specific chemical
TOXICITY

is a measure of the potential of a substance to produce a harmful effect on a living system.
Three Pathways through which People Can Be Exposed to Chemicals:

- Inhalation (breathing)
- Oral (ingestion)
- Dermal (skin contact)
The Difference Between Exposure and Dose

Exposure = opportunity for contact
The Difference Between Exposure and Dose

Dose = the amount of a chemical in the body
Exposure Evaluation

- Absorption
- Distribution
- Metabolism
- Excretion
Absorption Distribution Metabolism Excretion

**Absorption** into gastrointestinal tract, lungs, and through the skin

**Distribution** from blood stream to rest of body, including fat, brain, liver

**Metabolism** \[ X \xrightarrow{\text{enzymes}} Y \]
\[ x = \text{absorbed, distributed chemical} \]
\[ y = \text{metabolite} \]

**Excretion** via exhaled breath; from liver through bile/feces; from kidneys through urine
The **HALF-LIFE** of a chemical in the body is defined as the amount of time it takes the body to get rid of **ONE** HALF of an amount of the chemical.
## Biological Half-Life

<table>
<thead>
<tr>
<th>CHEMICALS</th>
<th>HALF-LIFE (in humans unless otherwise noted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>1-3 hours</td>
</tr>
<tr>
<td>Cadmium</td>
<td>10-30 years</td>
</tr>
<tr>
<td>Caffeine</td>
<td>3.5 hours</td>
</tr>
<tr>
<td>Ethanol</td>
<td>2-4 hours</td>
</tr>
<tr>
<td>Toluene</td>
<td>72 hours (whole blood)</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>4-7 hours (for metabolite)</td>
</tr>
<tr>
<td>Xylene</td>
<td>20-30 hours</td>
</tr>
<tr>
<td>Tetrachlorethylene</td>
<td>33-72 hours</td>
</tr>
</tbody>
</table>
CHEMICALS OF CONCERN =

chemical species studied in detail in the risk assessment process
Since different chemicals cause different types of health effects, results of the risk assessment are different for each different type of health effect.

Type 1: Chemicals that Cause Health Effects After Chronic Exposures
Threshold = Dose below which no effect is seen

NOAEL = No Observable Adverse Effect Level
Chronic Toxicity Threshold/NOAEL

Response % vs. Dose (mg/kg/day)

- NOAEL: doses causing no effect
- Threshold dose: 

Graph showing a dose-response curve with a NOAEL and threshold dose indicated.
What is a Safe Dose? Who Determines that Value?

Safe Values are set by public policy to be protective of the public health

- IRIS (Integrated Risk Information System, USEPA)
- HEAST (Health Effects Assessment Summary Tables, USEPA)
What is a safe dose? Who determines that value?

- Values are called Reference Doses (ingestion and dermal pathways) -- RfD
- Reference Concentrations (for the inhalation pathway) -- RfC
RfD = \frac{\text{NOAEL}}{(\text{UF} \times \text{MF})}

Where: \text{UF} = \text{Uncertainty Factor}
\text{MF} = \text{Modifying Factor}

Because the threshold dose value is difficult to know for certain, the UF and MF provide a factor of safety that is protective of the public health.
Safety Factor = SF

Multiples of 10

Accounts for:

❖ uncertainty in using animal studies to determine doses for humans
❖ variation in susceptibility among people exposed
❖ professional judgment and knowledge of the substance itself
Does the Safety Factor Work?

YES.
Chronic Toxicity
Safety Factor/Reference Dose
Hazard Quotient

- a method to assess whether a dose may potentially have a health effect
- ratio of exposure (dose) of a substance to the reference dose (RfD) for that substance
Generalized Hazard Quotient Equation

Hazard Quotient = \( \frac{CC \cdot CR \cdot CF \cdot EF \cdot ED}{BW \cdot AT} \) / RfD

RfD: reference dose
CC: Conc. of contaminants
CR: contact rate
ED: exposure duration
EF: exposure frequency
CF: conversion factor
AT: averaging time
BW: body weight
Hazard Quotient = \frac{\text{Dose (mg/kg/day)}}{\text{RfD (mg/kg/day)}}
If the hazard quotient is greater than one (a person is exposed to more of the substance than is acceptable under public policy), there is a possibility that a health effect may occur.
Hazard Index

- Calculated as sum of hazard quotients
- Hazard Index = sum of Hazard Quotients (individual organ or system)
- Used when potential exists for exposure to more than one substance that may affect a specific target organ or organ systems
Results of the Risk Assessment for Chemicals Causing Health Effects After Chronic Exposures:

The Answer is NOT:

- A Number
- A Probability
- A “Yes”/“No”

The Answer IS: “Maybe”/“No”
TYPE 2:
CARCINOGENIC CHEMICALS
**EPA Weight-of-Evidence Classification System**

### Group A. Human Carcinogen
--indicates that there is sufficient evidence from epidemiological studies to support a cause-effect relationship between substance and cancer.

### Group B. Probable Human Carcinogen

**B₁:** classified on the basis of sufficient evidence from animal studies and limited epidemiological evidence

**B₂:** classified on the basis of sufficient evidence from animal studies and epidemiological data that is inadequate or non-existent
<table>
<thead>
<tr>
<th>Group C. Possible Human Carcinogen</th>
<th>indicates that there is limited evidence from animal studies and no epidemiological data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group D. Not Classifiable as to Human Carcinogenicity</td>
<td>data from human epidemiological and animals studies are inadequate or completely lacking, so no assessment as to the substance’s cancer-causing hazard is possible</td>
</tr>
</tbody>
</table>
Group E. Evidence of Noncarcinogenicity for Humans - substances in this category have tested negative in at least two adequate (defined by EPA) animal cancer tests in different species and in adequate epidemiological and animal studies. Classification in group E is based on available evidence; substance may prove carcinogenic under certain conditions.
To be protective of the public health, EPA has established policy that there is no threshold value for any carcinogen.
Dose Response for Carcinogens

Response (%) vs. Dose (mg/kg/day)

Lowest Dose Given

- Lowest Dose: 20
- Lowest Response: 50

- Dose: 1,000 to 50,000
- Response: 0 to 120
Dose Response for Carcinogens

Extrapolated line from the smallest dose known to cause and effect to zero
Risk = \text{CSF} \cdot \text{CC} \cdot \text{CR} \cdot \text{CF} \cdot \text{EF} \cdot \text{ED} \\
\quad \text{BW} \cdot \text{AT}

\text{CSF: cancer slope factor}
\text{CC: Conc. of contaminants}
\text{CR: contact rate}
\text{CF: conversion factor}
\text{ED: exposure duration}
\text{EF: exposure frequency}
\text{AT: averaging time}
\text{BW: body weight}
## Food-Related Risks

<table>
<thead>
<tr>
<th>Risk</th>
<th>Average Lifetime Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating one tablespoon of peanut butter per day</td>
<td>$1.4 \times 10^{-4}$</td>
</tr>
<tr>
<td>Drinking one pint of milk per day</td>
<td>$1.4 \times 10^{-4}$</td>
</tr>
<tr>
<td>Eating one-half pound of steak per week</td>
<td>$2.1 \times 10^{-5}$</td>
</tr>
</tbody>
</table>
# Everyday Cancer Risks

<table>
<thead>
<tr>
<th>Incident</th>
<th>Average Lifetime Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cancers</td>
<td>0.25</td>
</tr>
<tr>
<td>One transcontinental round trip by air per year*</td>
<td>$7 \times 10^{-5}$</td>
</tr>
<tr>
<td>Natural background radiation at sea level</td>
<td>$1.4 \times 10^{-4}$</td>
</tr>
<tr>
<td>Average diagnostic X-ray</td>
<td>$1.4 \times 10^{-4}$</td>
</tr>
<tr>
<td>Smoking</td>
<td>$8.4 \times 10^{-2}$</td>
</tr>
<tr>
<td>Sharing A room with a smoker</td>
<td>$7.0 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

*Estimated based on exposure to cosmic rays

Source: Crouch and Wilson, 1982
## Estimated Average Annual and Average Lifetime Risks of Death for United States Residents from Specific Incidents

<table>
<thead>
<tr>
<th>Incident</th>
<th>Average Annual Risk</th>
<th>Average Lifetime Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle accident</td>
<td>$2.4 \times 10^{-4}$</td>
<td>$1.7 \times 10^{-2}$</td>
</tr>
<tr>
<td>Falls</td>
<td>$6.2 \times 10^{-5}$</td>
<td>$4.3 \times 10^{-3}$</td>
</tr>
<tr>
<td>Drowning</td>
<td>$3.6 \times 10^{-5}$</td>
<td>$2.5 \times 10^{-3}$</td>
</tr>
<tr>
<td>Fires</td>
<td>$2.8 \times 10^{-5}$</td>
<td>$1.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>Firearms</td>
<td>$1.0 \times 10^{-5}$</td>
<td>$7.0 \times 10^{-4}$</td>
</tr>
<tr>
<td>Electrocution</td>
<td>$5.3 \times 10^{-6}$</td>
<td>$3.9 \times 10^{-4}$</td>
</tr>
<tr>
<td>Floods</td>
<td>$6.0 \times 10^{-7}$</td>
<td>$4.2 \times 10^{-5}$</td>
</tr>
<tr>
<td>Lightning</td>
<td>$5.0 \times 10^{-7}$</td>
<td>$3.5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Animal bite or sting</td>
<td>$2.4 \times 10^{-7}$</td>
<td>$1.7 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

Source: Crouch and Wilson, 1982
For carcinogens, risk will be additive.

\[
\text{Risk}_{\text{Total}} = \text{Risk}_{\text{Benzene}} + \text{Risk}_{\text{Chromium}}
\]

\[
\text{Risk}_{\text{Nickel}} + \text{Risk}_{\text{Tetrachloethylene}}
\]
Results of the Risk Assessment for Carcinogens

- Compare Calculated Risk Number with Public Policy

- Answer is “Yes”/ “No”
“It should be emphasized that the linearized multistage procedure leads to a plausible upper limit to the risk that is consistent with some mechanism of carcinogenesis. Such an estimate, however, does not necessarily give a realistic prediction of the risk. The true value of the risk is unknown and may be as low as zero.”

--US Environmental Protection Agency, 1986
Cancer risk is unverifiable.

It is lost in the noise of natural occurrence.
Indoor Air as a Source of Chemical Exposures and Discomfort

Indoor air concentrations of chemicals are typically much greater than outdoor concentrations and these indoor levels are derived from sources unrelated to outdoor air.
Indoor Air as a Source of Chemical Exposure and Discomfort

For example:
We have shown that about 20 common activities can result in sharply increasing personal exposures over 5-11 hr may be increased by factors of 10-100 compared to exposures during periods of little activity… These common activities and indoor sources result in personal exposures that far exceed observed outdoor concentrations, even in chemical manufacturing and petroleum refining areas.

(Wallace et al., 1989)
### Rational Approach to Medical Evaluation of Possible Toxic Exposures to Environmental Chemicals

![Diagram showing the flow from Exposure to Dose to Health Effects.]

<table>
<thead>
<tr>
<th>Environmental Testing</th>
<th>Biological Testing</th>
<th>Medical Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Air</td>
<td>a) Blood</td>
<td>a) History</td>
</tr>
<tr>
<td>b) Water</td>
<td>b) Urine</td>
<td>b) Physical Exam.</td>
</tr>
<tr>
<td>c) Soil</td>
<td>c) Breath</td>
<td>c) Laboratory</td>
</tr>
<tr>
<td>d) Food</td>
<td>d) Tissue</td>
<td>d) Radiology</td>
</tr>
</tbody>
</table>
Structures

- Butadiene
- Benzene
- Styrene
- Butadiene Monoepoxide
- Benzene Oxide
- Styrene Oxide
Butadiene Metabolism

Activation
Detoxification

Humans  Rats  Mice

Cancer  ?  ?  ?
Comparison of DNA Repair

![Graph showing the percent DNA repair efficiency for various species: Human, Shrew, Mouse, Rat, Hamster, Cow, and Elephant. The graph indicates that humans have the highest repair efficiency, followed by elephants and cows, with the lowest efficiency in shrews.]
<table>
<thead>
<tr>
<th>Chemical</th>
<th>2u-Nephropathy</th>
<th>Kidney Tumor Response (Male Rats Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unleaded Gasoline</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Isophorone</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
### Chemicals that Induce 2u-Globulin Nephropathy and Kidney Tumors in Male Rats

(Cont.)

<table>
<thead>
<tr>
<th>Chemical</th>
<th>2u-Nephropathy</th>
<th>Kidney Tumor Response (Male Rats Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethyl Methylphosphonate</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Perchloroethylene</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pentachloroethane</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Hexachloroethane</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Absence of $\alpha_2u$-Globulin in Human Kidneys
Rodents Are Poor Predictors of Carcinogens For Humans

Wrong 95% of the Time!

Correct Only 5% of the Time!
The Standard carcinogen tests that use rodents are an obsolescent relic of the ignorance of past decades. At that time, extreme caution made sense. But now tremendous improvements of analytical and other procedures make possible a new toxicology and far more realistic evaluation of the dose levels at which pathological effects occur.

Toxicity Data Evaluation

A rational approach towards assessing the risk that a chemical might pose requires mechanism-of-action-oriented research to four principal points.

For example, let us look at the maximum tolerated dose (MTD). Approximately two-thirds of the NTP carcinogens would not be positive, i.e., not be considered as carcinogens, if the MTD was not used.

*Federal Register Vol. 57, No. 138
July 17, 1992, Pg. 31723*
Rebuttals of Animal Data to Use in Toxic Torts

Poor predictor of target organ toxicity
Low degree of concordance
High degree of false positives
Exposure → Dose → Response

Animals

Humans

Animals

Humans

Animals

Humans

Animals

Humans

Animals

Humans

Animals

Humans

Animals

Humans

Animals

Humans
Chemical Essential to Health that Causes Cancer in Rodents

USEPA → safe dose calculated by USEPA procedures = less than 2 Units

National Research Council → dose recommended by National Research Council = 400 Units
PAHs in Coal-Tar Shampoo (mg/kg)
Cancer Potency Factors Overestimate Actual Risk

Predicted Incidence of Cancer Using USEPA Derived Cancer Potency Factors and OSHA Permissible Exposure Levels

Actual Incidence of Cancers Using SEER Incidence and Mortality Data and Gehring, 1969
Regulations Protect

They Do Not Predict
Carcinogens and Neurotoxicants Released During 1991

Carcinogens - 15,850,466 lbs.
- Known Human Carcinogens (A) - 6,128,266 lbs.
- Probable Human Carcinogens (B1) - 802,583 lbs.
- Probable Human Carcinogens (B2) - 8,919,618 lbs.

Neurotoxicants - 10,329,084 lbs.
Neurotoxicants Released in Houston/Galveston Area, 1991

N-Butyl Alcohol - 3,067,693 lbs
Carbon Disulfide - 962,663 lbs
Styrene - 2,455,353 lbs
Xylenes - 2,361,747 lbs
Cumene - 1,215,434 lbs
Freon 113 - 263,970 lbs
2,6-Dinitrotoluene - 1,500 lbs
Acrylamide - 714 lbs
Rational Approach to Medical Evaluation of Possible Toxic Exposures to Environmental Chemicals and Causation Criteria

- Exposure and dose
- Literature precedence
- Confounder analysis
- Temporality
- Biological plausibility and consistency
Symptoms

There are very few symptoms that are relatively specific for a particular disease and thus useful in the diagnosis of the disease.

Symptoms are medically defined as:

...any subjective evidence of disease or of a patient’s condition, i.e., such evidence as perceived by the patient; a change in a patient’s condition indicative of some bodily or mental state. (Dorland’s Illustrated Medical Dictionary, 27th edition)
Signs

Signs provide some tangible form of evidence which assists in the final determination of the true cause of the symptoms and the disease.

A sign is defined as

…*any objective evidence of a disease, such evidence as is perceptible to the examining physician, as opposed to the subjective sensations (symptoms) of the patient*. (Dorland’s Illustrated Medical Dictionary, 27th edition)
Individual Risk Evaluation

Exemplary 45-Year-Old Male
Fit, normo-tensive, non-diabetic, non-smoker, non-drinker, normal body weight.
Risk of death from all causes in next 10 years - 3.8 % \((3.8 \times 10^{-2})\)

Stroke
1/1,000 vs. 9/1,000

Esophageal Cancer
1/1,000 vs. 3/1,000

Heart Attack
1/1,000 vs 69/1,000

Lung Cancer
1/1,000 vs 12/1,000

Liver Cirrhosis
1/1,000 vs 2/1,000

Kidney Failure
1/1,000 vs 2/1,000

Diabetes Mellitus
1/1,000 vs 22/1,000

Conclusion:
Lifestyle risks far outweigh risks from environmental/clinical exposure

45-Year-Old Male
Morbidly obese, hypertension, diabetic, smoker, drinker, sedentary.
Risk of death from all causes in next 10 years - 16.3 % \((1.63 \times 10^{-1})\)
Comparison of Risk of Death

- **EPA Acceptable Population Risk**
- **Exemplary 45-Year-Old Male**
- **45-Year-Old Male**
Contributory Risk

Qualitative characterization of contributory risk

Need to account for direct and indirect sources of risk in an assessment

Voluntary actions (such as buying a jet ski, RV or snowmobile) contribute to involuntary risk in others
Contributory Risk

An RV is bought → The RV maker released toxics while making the RV → The RV maker’s suppliers released toxics in making components → The suppliers to the suppliers released toxics

Total Toxic Emissions = Direct Emissions & Indirect Emissions
Contributory Risk

A car is bought
The car maker released toxics while making the car
The car maker’s suppliers released toxics in making components
The suppliers to the car maker released toxics

Total Toxic Emissions =
Direct Emissions & Indirect Emissions
Common Carcinogenic Hazards

White Bread (Furfural)
Common Carcinogenic Hazards

CARROTS
(Caffeic acid)
Common Carcinogenic Hazards

MUSHROOMS
( Hydrazines )
Common Carcinogenic Hazards

All chargrilled food contains Polycyclic Aromatic Hydrocarbons (PAHs)
## Common Carcinogenic Hazards Associated with Daily Lifestyle, 1:100,000

<table>
<thead>
<tr>
<th>Cosmic ray risks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• one transcontinental flight per year</td>
<td>21</td>
</tr>
<tr>
<td>• airline pilot, 50 hrs/month at 35,000 feet</td>
<td>35</td>
</tr>
<tr>
<td>Other radiation risks</td>
<td></td>
</tr>
<tr>
<td>• natural background at sea level</td>
<td>105</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
</tr>
<tr>
<td>• cancer only</td>
<td>8,400</td>
</tr>
<tr>
<td>• all effects (including heart disease)</td>
<td>21,000</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>• regular use of contraceptive pills</td>
<td>140</td>
</tr>
</tbody>
</table>
Post Risk Assessment
Follow-up

Where risk assessment stops, risk management begins
Risk Management

- If the answer is “YES” for carcinogens, and/or
- If the answer is “MAYBE” for chemicals causing health effects after chronic exposures,

Undertake appropriate risk management
Risk Management

- Will be undertaken by controlling exposures
- Will be undertaken as part of the permitting process
- Will be undertaken to protect public health