Let's tie it all together.

Scenario: You live near a Superfund site. The federal or state government has notified you that the water is contaminated. They have performed a risk assessment for the site using the four steps. If there is a heath risk, the state or federal agency will aim to reduce the exposure (for example, removing contaminated soil or using a water filter).

1. Is the pollutant hazardous? Based on what we know about the pollutant, can it harm humans?

2. Are there exposure routes? What is the concentration of the pollutant at the point of contact? What is the calculated Lifetime Average Daily Dose?

3. What is the expected response to the calculated dose? Is the pollutant proven to cause cancer? Does the pollutant cause any non-cancer health effects?

4. What is the excess increased cancer risk for people living in the area who are drinking the water at the measured concentration every day for 350 days out of the year for their entire life (78 years)?

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Understanding Environmental Health Risk Assessment

Risk is the likelihood that that something bad might happen. Did you know that one in four Americans live within three miles of a hazardous site? Because of this, we need to know what risks these sites pose to humans. Environmental health risk assessment estimates the possibility that something negative will happen as a result of an exposure to a hazardous pollutant.

Risk Perception

A number of factors affect how we see risk. In general, the risks that harm people are sometimes very different from the risks that worry, concern, and upset people. We may perceive risk to be greater when it is out of our control, when we feel we have no choice about the risk, when the risk seems unfair, and when it may affect our children. Let's compare the risks in our society, see Figure 1 below.

Things that play a role in environmental risk assessment are:

Probability: Likelihood or chance that a certain result will occur
Uncertainty: Lack of precise knowledge or understanding of the hazardous pollutant
Variability: Difference between individuals, such as age, sex, nutritional status, family traits, life style, and state of health.

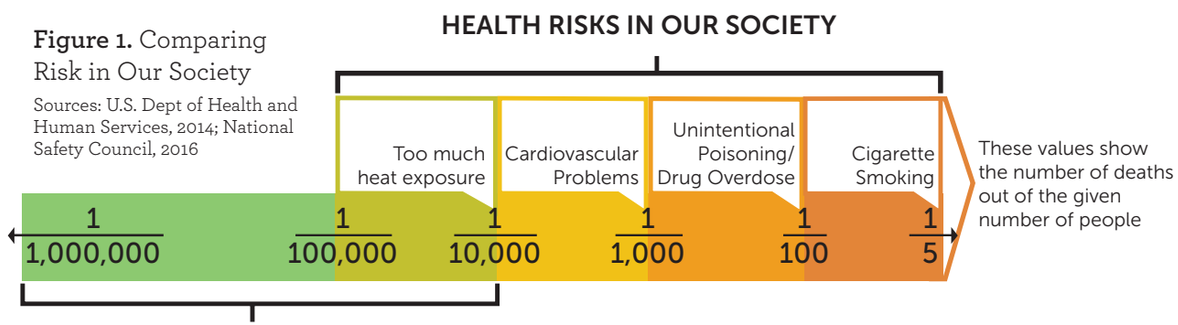


Figure 1. Comparing Risk in Our Society

Sources: U.S. Dept of Health and Human Services, 2014; National Safety Council, 2016

REGULATORY STANDARDS are set to keep the public's risk in this range.

These standards consider health outcomes, costs, and whether we have the technology that can remove the pollutant. Examples are: Maximum Contaminant Levels for water and National Ambient Air Quality Standards

STEP 1 | HAZARD IDENTIFICATION
Does the pollutant harm us?

The first step in the environmental health risk assessment process is **to figure out if the pollutant can cause harm to humans.** To do this, people study whether a chemical exposure caused a number of people to get sick in a certain location. Other studies may be done in laboratories using animals or cells (the basic building blocks of all living things).

STEP 2 | EXPOSURE ASSESSMENT
How much of a pollutant is present in the environment? Are we exposed? If so, how and how much are we exposed to?

CONCENTRATION of chemical in water, air, soil, or food.

DAILY INTAKE How much will we ingest or inhale?

BIOAVAILABILITY How much of a pollutant is absorbed into the body after exposure?

YEARS we may live in an area; 30 years is the average amount of time a family stays in one home

DAYS we could be exposed per year, 350 days is used to account for travel.

LIFETIME 78 years is used for the LADD to determine cancer risk. 30 years is used for the ADD for non-cancer risks.

x

BODY WEIGHT How much the average adult (80 kilograms or 176 pounds) or child weighs at a certain age.

$$= \frac{\text{milligrams of pollutant}}{\text{kilograms of body weight}} \text{ per day} \rightarrow \text{Lifetime Average Daily Dose (LADD) or Average Daily Dose (ADD)}$$

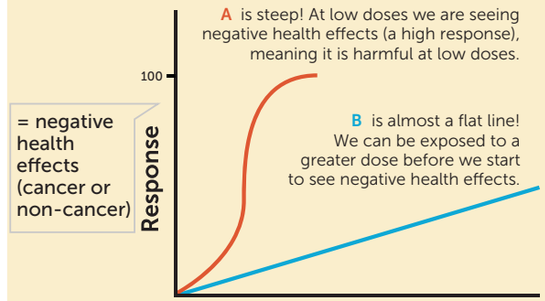
Exposure assessment is when we look at how much of a pollutant is present in the environment and how someone might be exposed. This information is then used to calculate and estimate the exposure. The pollutant has to be in the same place and time as the person or population. We need to be extra careful with sensitive populations such as children, older people, people who are already sick, and pregnant woman because they may be harmed more than a regular adult.

The exposure assessment calculation can make two types of numbers: the **lifetime average daily dose (LADD, when we know that the pollutant can cause cancer) and average daily dose (ADD, when the pollutant has not been proven to cause cancer).** Check out the graphic above to see what goes into an exposure assessment. The numbers used are based on average human activities.

If we are exposed to a hazardous pollutant, we need to know:

- How are we exposed?
- What is the point of contact: drinking water (ingestion), indoor/outdoor air (inhalation), soil (accidental ingestion), or through our skin (absorption)?
- How long?
- What other chemicals are we exposed to?
- What is our age, sex, nutritional status, lifestyle, and state of health?
- What are the risks we may be born with (family traits)?

STEP 3 | DOSE-RESPONSE EVALUATION
What dose can cause harm or make us sick?



A dose-response assessment looks at what can happen if we are exposed and how much of a pollutant it takes to cause harm or make us sick. Once we calculate the exposure (**LADD or ADD**, Step 2) we can look at past research and estimate harm (Step 1 and Step 3). Each pollutant can cause different types of harm and each of us may respond differently.

Risk characterization uses the estimated exposure to determine whether that exposure will cause harm. This activity is different based on whether the pollutant can cause cancer or has non-cancer health effects. For pollutants that do not cause cancer, we look at risk by dividing the **ADD** (Step 2) to either a oral reference dose, inhalation reference concentration (RfD, RfC, used by the U.S. Environmental Protection Agency) or by a minimal risk level (MRL, used by the Agency for Toxic Substances and Disease Registry). This is called the **Hazard Quotient.** The RfD, RfC, and MRL are the amount of a chemical that one can have daily for a certain amount of time without developing non-cancer health problems (Step 3).

$$\text{Hazard Quotient} = \frac{\text{Average Daily Dose}}{\text{Reference Dose or Minimal Risk Level}}$$

Greater than 1	non-cancer health effects are likely
Less than 1	non-cancer health effects are unlikely

STEP 4 | RISK CHARACTERIZATION
Based on the exposure to the pollutant, what are the potential health risks?

$$\text{Increased Excess Lifetime Cancer Risk} = \text{Lifetime Average Daily Dose} \times \text{Cancer Slope Factor}$$

For pollutants that do cause cancer, the U.S. Environmental Protection Agency has an oral slope factor or an inhalation unit risk. We use the slope factor or unit risk to calculate an **Increased Excess Lifetime Cancer Risk** that may occur from the **LADD** (Step 2). This number can tell us the cancer risk above the existing likelihood of developing cancer.

Now let's see how these steps work together!