Risk Assessment, Management and Communication

- Frumkin H [Ed.] Environmental Health: From Global to Local, 3rd Ed. Chapter 27 "Risk Assessment" (by Scott Bartell), Chapter 28 "Risk Communication" (by Vincent T. Covello)
- Risk Assessment
  - Hazard identification + dose-response assessment + exposure assessment + risk characterization
  - Dose-response ← animal experiment + statistical model
  - De minimis risk: risk management concept
  - Interdisciplinary new techniques: CVM, CRA, etc.
- Risk Communication
  - Two-way exchange of information about environmental, health, and safety threats
  - Core public health function to inform the public, achieve behavioral change, provide warnings of disasters and emergencies
  - Applicable to emergency situation
  - Practiced by governmental agencies, NGO, private sector
  - Based on an understanding of the determinants of risk perception
- Reference web pages and books for risk communication
  - https://www.ecdc.europa.eu/sites/default/files/media/en/publications/Publications/risk-communication-literary-review-jan-2013.pdf
  - 岩田健太郎 (2014)『「感染症パニック」を防げ！　リスク・コミュニケーション入門』光文社新書，ISBN 978-4-334-03828-1

What's Risk Assessment?

- The process of identifying and evaluating adverse events that could occur in defined scenarios
  - Scenarios must be defined, including many events
  - Major assessors: (1) What can happen? (2) How likely is it to happen? (3) What are the consequences if it does happen?
  - In environmental health settings: risk assessors focus on "health impacts" ← exposure to a particular agent / working in, living in, or visiting a particular environment
    - For instance, assessment of drinking water with chemical or microbial contaminants, or of eating fish contaminated with mercury or PCBs
  - Environmental health risk assessment: quantitative framework for evaluating and combining evidence from toxicology, epidemiology and other disciplines → decision making
- Risk assessment does not generate new evidence, but synthesize existing scientific information to address specific regulatory or policy issues.
- Official guidances
  - USEPA: https://www.epa.gov/risk > https://www.epa.gov/risk/risk-assessment-guidance
    - Recent additions: https://www.epa.gov/risk/recent-additions-risk-assessment
  - EU-OSHA: https://osha.europa.eu/en/legislation/guidelines/guidance-risk-assessment-work
  - WHO: https://www.who.int/emergencies/risk-assessments > https://www.who.int/publications/i/item/9789240035720

Process

- Example: chloroform (as a by-product of water chlorination to sterilize) ingestion at average concentration of 1 to 90 μg/L in USA drinking water systems. Water chlorination is very effective to eliminate cholera and other waterborne diseases. Exposure to chloroform may increase cancer.
- In 1970s, the impossibility of "zero-risk" has been realized.
  → determination of acceptable limits for concentrations of pollutants in air, water, soil, biota and in emissions.
- In 1983, NRC report "Risk Assessment in the Federal Government" (a.k.a. Red Book) divided it into 4 elements
  - hazard identification
  - dose-response assessment
  - exposure assessment
  - risk characterization

Hazard identification

- Identifying and selecting environmental agents and health effects for assessment
  - causal inference for particular health outcomes
    ← strength of toxicological/epidemiological evidences
  - single agent / single health effect → straightforward
  - broad inquiry for multiple agents / multiple health effects → selection of key agents / most important health effects
    - In 1970s, widespread concern with the potential contribution of environmental pollution rising cancer rates → assessments focused on cancer
    - High level chloroform in drinking water can cause cancer in lab. animals (EPA, 2001). The slight increases of bladder, rectal, colon cancer were observed in humans who drink chlorinated drinking water ← many epidemiological studies, but unclear whether it was caused by chloroform or not.
    - fish with low level chemical contaminants is another example
- IARC (International Agency for Research on Cancer) published more than 90 monographs and classified agents into several weight of evidence categories (Group 1, Group 2A, Group 2B, Group 3, Group 4)

Dose-Response Assessment

- Attempts to describe the quantitative relationship between exposure and disease
  - Direct evidence → mathematical dose-response model is unnecessary: Rare case
  - Usually no direct evidence → relying on mathematical models
  - Mathematical models may also be used to adjust effect estimates for differences in species, gender, race, ... (confounders)
- The most famous dose-response model for cancer "Linearized Multistage Model": Assuming every molecule of exposure adds more risk to cancer
  - "Threshold model" assumes that nobody exposed at a level below a critical threshold dose will develop cancer as the result of exposure
  - Various functions may be applicable (Williams et al., 2011) https://doi.org/10.1111/j.1539-6924.2010.01518.x

Example of Dose-Response Assessment

- Water chlorination is widely used as the method of disinfection for drinking water.
  - Chloroform is one of the toxic byproducts
- Carcinogenic effects of chloroform on male rats (Code in R)
  - `Haas1994 <- data.frame(dose = c(0, 19, 38, 81, 160), tested = c(301, 313, 148, 48, 50), kidneytumor = c(4, 4, 4, 3, 7), proportion = c(0.013, 0.013, 0.027, 0.063, 0.140))`
  - `plot(proportion ~ dose, data=Haas1994, type="b")`
  - `fit <- glm(cbind(kidneytumor, tested-kidneytumor)~dose, data=Haas1994, family=binomial)`
  - **`# Logistic regression`**
  - `summary(fit)`
  - `exp(coef(fit)[2])`
- Then we can get the estimate of odds ratio as 1.016 in male rats.
- Haas (1994) estimated 0.00011 (/mg/kg/day) cancer risk added for lifetime based on 2 stage model.
  - Haas (1994) https://doi.org/10.1111/j.1539-6924.1994.tb00081.x

Exposure Assessment

- Estimation/measurement of the following aspects of human exposures to the agent of concern (NRC, 1994)
  - magnitude
  - duration
  - timing
- Often quite difficult, especially in the case of time-varying behavior such as the frequency and amounts of water consumption, origins of soil and dust unintentionally to ingest or to inhale
- Full profile of each individual's exposures over time is ideal, but usually unavailable. Usually using time-averaged exposure rates, especially media contact rates
  - Chloroform in drinking water (> 90μg/L): drinking water ingestion + skin absorption and inhalation in bathing, ...
  - EPA assume that an adult drinks 2L water: if the one's body weight is 70kg, the exposure is 2 x 90 / 70 = 2.6 μg/kg/day.

Risk Characterization: The Final Step

- Combining the information from the other 3 steps to estimate the level of response for the identified health effects at the specific level of exposure
- Terms to estimate
  - relative risk: P(d)/P(0)
  - additional risk (absolute risk): P(d)-P(0)
  - attributable risk (excess risk): (P(d)-P(0))/(1-P(0))
- Chloroform: 0.0026 mg/kg/day x 0.00011 (/mg/kg/day) = 3 in 100 million (0.0026 is based on EPA, 0.00011 is based on Haas).
- The Red Book emphasize the uncertainties with this step.
  - Qualitative uncertainties: carcinogenicity of low exposure
  - Quantitative uncertainties: the shape of dose-response model. Including the control (zero dose) data makes the estimate interpolated, not extrapolated
- Including other byproducts, assessment for lifetime cancer risk caused by water chlorination was done in Taiwan. https://doi.org/10.1006/enrs.2000.4102

Risk Management

- Chloroform in drinking water causes 3 in 100 million kidney cancer.
  - 38% in women and 46% in men were killed by cancer in USA
  - "3 in 100 million" is a drop in the bucket, so that nobody would care such a drop.
- What should a risk manager do?
  - "*de minimis risk*" concept
  - risk-benefit analysis
  - cost-benefit analysis
    - contingency valuation method (CVM) or comparative risk assessment (CRA) should also be applied
  - decision analysis or alternative analysis
  - paying attention to the "precautionary principle"
- National Research Council (2009) "Science and Decisions: Advancing Risk Assessment." Washington, DC: The National Academies Press. https://doi.org/10.17226/12209. – so called "Grey book"

What's Risk Communication?

- One of the core practices for public health professionals.
- Definition: "Inform, educate and empower people about health issues" (CDC, 2008) as a special category of health communication, included in 10 essential public health services.
- Two way exchange of information about environment, health, and safety threats (incl. hazardous waste, water contamination, air pollution, radiation, ...).
- Four major types by objectives (Covello, 2010)
  - Information and education
  - Behavioral change and protective action
  - Disaster warning and emergency notification
  - Joint problem solving and conflict resolution
- Two types by situation (Sandman, 2003; 岩田, 2014)
  - Crisis communication: High-outrage, high-hazard
  - Non-crisis communication: Other situation

7 essential rules for effective risk communication (slightly modified from Covello, 2010)

- Accept and involve the receiver of information as a legitimate partner: People have rights to participate in decisions
- Plan and tailor risk communication strategies: Differential goals, audiences, channels require different strategies
- Listen to your audience: Whether people have more interests in psychological aspects or technical aspects? Identification of audience's true concern is essential
- Be honest, frank, and open: Trust and credibility are among the most valuable assets of a risk communicator
- Coordinate and collaborative with other credible sources: With referrals to credible, neutral sources of information, communications are enhanced.
- Plan for media influence: The media plays a major role in transmitting information. Know how the media delivers.
- Speak clearly, with compassion: Technical terms/jargon will be a barrier. Abstract/unfeeling/emotional words must be avoided.

Covello VT (2010). Risk communication. *Environmental health: From global to local*, 1099-1140.

Outcome of Effective Risk Communication

- Informed decision making
  → Establishing public confidence in the ability of individuals and organization to deal with an environmental, health, or safety risk
- Provides people with timely, accurate, clear, objective, consistent, and complete risk information
- Creates an informed public:
  - Involved, interested, reasonable, thoughtful, solution oriented, cooperative and collaborative
  - Appropriately concerned about the risk
  - More likely to engage in appropriate behaviors

Risk Communication Models (1)

- Risk perception model
  - Paradox in risk perception: difference between the risk to kill or harm people and the risk to alert them
    - No correlation between the ranking of hazards by the statistics on expected annual mortality and the ranking of the same hazards by how upsetting they are to people.
    - (eg.) Ebola virus made no death in Japan in 2014, but the people were afraid of it due to TV/newspaper info.
  - The paradox is explained by the factors affecting how risks are perceived → Important risk perception factors are:
    - Trust
    - Voluntariness
    - Controllability
    - Familiarity
    - Fairness
    - Benefits
    - Catastrophic potential
    - Understanding
    - Uncertainty
    - Delayed effects
    - Effects on children
    - Effects on future generations
    - Victim identity
    - Dread (~ fear)
    - Media attention
    - Accident history
    - Reversibility
    - Personal stake
    - Ethical or moral nature
    - Human vs natural origin

Risk Perception Model (cont'd) and Other Models

- Sandman (1989), Slovic (2000), Fischhoff (1995) and others revealed that people often assess risk more in terms of these perceived risk factors than in terms of actual potential for harm or hazard
  - For the public, Risk = Hazard + Outrage
  - Outrage often takes on strong emotional overtones, in turn, makes people perceive exaggerated risk than actual
  - (eg.) Considering NIMBY controversy, an unfair risk is often perceived as more risky. Why other prefectures denied to accept solid wastes from Fukushima?
- The mental noise model: Considering how people process information under the serious stress. Stress causes mental noise, then information processing is damaged.
- The negative dominance model: Considering the processing of negative and positive information in high-concern and emotionally charged situations. Negative words often dominates.
- The trust determination model: Considering importance of trust in effective risk communications. Determinants of trusts are: (1) Listening, caring, empathy, compassion (50%), (2) Competence, expertise, knowledge (15-20%), (3) Honesty, openness, transparency (15-20%), (4) Other factors (15-20%).

Challenges to effective risk communication

- Media selectivity / Media bias
  - Newsworthiness
  - Division of labor
  - Generalist journalists
  - Resources
  - Objectivity and balance
  - Career advancement
  - Watchdogs
  - Source dependency
  - Competition
  - Deadliness
  - Information compression
- Factors to create misperception / misunderstanding
  - Availability, conformity, overconfidence in one's ability to avoid harm, confirmatory bias, uncertainty, reluctance

Strategies for effective risk communication

- Preparing a comprehensive risk and crisis communication plan
- Message mapping: contributes to clarity on what is to be communicated
  - (template example)
    Stakeholder:
    Question or concern:

Key Message 1	Key Message 2	Key Message 3
Supporting information 1-1	Supporting information 2-1	Supporting information 3-1
Supporting information 1-2	Supporting information 2-2	Supporting information 3-2
...		

  - Crucial final step: Systematic message testing using standardized procedures
- Using and communicating high-quality information
- Fostering comprehensive, balanced media reporting
- Templates
  - (NOAA) https://coast.noaa.gov/data/digitalcoast/pdf/risk-communication-strategy.pdf
  - (CDC) https://emergency.cdc.gov/cerc/resources/templates-tools.asp

Action against infodemic – now essential for a good risk communication

- For the sound risk communication, (both intentional and unintentional) fake news and misinformation are big obstacles.
- WHO infodemic page
  - Infodemic management
    https://www.who.int/teams/risk-communication/infodemic-management
  - COVID-19 mythbusters
    https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters
  - Let's flatten the infodemic curve
    https://www.who.int/news-room/spotlight/let-s-flatten-the-infodemic-curve
- Joint statement by WHO, UN, UNICEF, UNDP, UNESCO, UNAIDS, ITU, UN Global Pulse, and IFRC: "Managing the COVID-19 infodemic: Promoting healthy behaviours and mitigating the harm from misinformation and disinformation" (23rd Sep. 2020)

  https://www.who.int/news/item/23-09-2020-managing-the-covid-19-infodemic-promoting-healthy-behaviours-and-mitigating-the-harm-from-misinformation-and-disinformation
- Editorial of Lancet Infectious Diseases (17th July 2020)
  https://doi.org/10.1016/S1473-3099(20)30565-X
  - "Vicious cycle": Politician's mislead → Sensation-seeking media's spread → Mistrust on the statements by the general public → Misleading become predominant
- Not only correction but also action to make people's mind changed is needed. However, the effective action is not fully proved.
  - "How to report misinformation online" by WHO

    https://www.who.int/campaigns/connecting-the-world-to-combat-coronavirus/how-to-report-misinformation-online