Environmental psychology, environmental genetics, risk assessment, and risk communication

- As Environmental Health (5) on 2 Nov. 2017
- Key Concepts
  - Environmental psychology considers health and behavior in sociophysical context, based on both objective and subjective measures of immediate and remote environmental conditions
  - Risk of disease is a function of both genetic and environmental factors, so that gene-environment interactions are important

Field definition of environmental psychology

- Assuming that a dynamic and reciprocal relationship exists between individual and groups and the environment where they live
- Sociophysical contexts affect the behavior and health: eg. the kind of dwelling, social and physical aspects of neighborhood.
  - "Sociophysical environment" means interdependent social and physical dimensions of settings jointly influencing an individual's psychological and physical well-being
- "Environment and behavior studies (EBS)" is alternative term.

Typical approaches of environmental psychology

- Concerned with the behavioral, emotional, and health outcomes of people's transactions with everyday environments
- Naturalistic field studies, emphasizing multidisciplinary perspective (incl. psychology, environmental design, geography, sociology, human ecology, natural resource management, government, public health)
- Behavior and health outcomes in relation to objective and subjective meanings
- User-oriented studies
- Events naturally occur, conditions may change during the course of the events
- Holistic and longitudinal approach
  → Sharing the focus with human ecology!!
  (Only the nominal difference?)

Levels of environmental analysis in sociophysical context

- Elemental: water, air, food, ...
- Individual: an individual's (1) body and physical, perceptual and cognitive abilities, (2) intellectual abilities, personal beliefs, values, attitudes, emotions, memories and experiences
- Stimuli: recognizable features of an environment that cause a personal perception or physical and/or psychological reaction
- Situation: sequences of individual or group activities and events occurring at a particular time and place
- Settings: socially structured and geographically bounded locations where certain kinds of activities and events regularly recur (eg. college classroom)
- Life domain: spheres of a person's life that encompass multiple situations and settings (eg. home, work, school, ...)
- Societal: overarching systems of beliefs and values, social and cultural norms, and social, political, and economic institutions that integrate life domains for large groups of people

Four different "world views" (Altman and Rogoff, 1987)

- **Trait** worldview tries to understand and predict the enduring, consistent features of physical settings and people as individual factors
- **Interactional** worldview posits stable relationships among traits and proposes basic "laws" that describe these relationships
- **Organismic** worldview tries to understand larger, more complete, more complex aggregates of factors, acknowledging that these factors may change or evolve over time
- **Transactional** worldview proposes that the factors that affect behavioral phenomena are part of a constant, dynamic, reciprocal milieu

Hurricane "Katrina" example

- Three parts of the event
  - awareness and preparation
  - immediate response ~ focusing on the use of common setting features as "affordances" (possibilities for action that are latent in an environment)
  - aftermath
- Environmental psychology's comprehensive approach
  - sense of place
  - place attachment
  - contextual transformation (sudden and dramatic context changes, resulting in fundamental behavior modification)

  * Please consider any other example you are familiar with.

Three principles of contextual analysis

- 1. The relationship between environment and health is influenced by interdependencies among immediate situations, immediate settings, and more remote environmental conditions
- 2. The different environments in which an individual participants exert a cumulative, synergistic effect on his or her health
- 3. Health is the result of an interaction among the objective features of the environments in which individuals participate, individual's perceptions of those features, and individuals' personal attributes

Neighborhood – basis of social capital

- Functions of both real and virtual neighborhood
  - Affiliation
  - Identity
  - Social support
  - Community
  - Information
  - Daily life
  - Recreation
- Problems
  - Conflict of real/virtual
  - Stimulation overload
  - Attentional fatigue
  - Digital divide

Neighborhood cooperates to prepare Christmas in Solomon Islands

Autumnal festival in Nagano

(cited from: https://www.realtor.com/advice/move/what-does-neighborhood-mean-anyway/)

Presence of nature

- Elemental: Natural scents, natural objects
- Individual: Clothing choices, eating choices
- Stimuli: Natural sounds (bird songs, ...), Natural surfaces (wood, rock, ...), Natural colors and textures, Views of nature through windows
- Situation: Outdoor meetings, meals, entertainment, gardening
- Setting: Outdoor recreation, relaxation
- Life domain: Outdoor occupations, location of residence, workplaces
- Societal: Nature preserves and wilderness areas

(cf.) Urbanization is an elimination of 'uncontrollable' nature from our living environments (Dr. Takeshi Yoro)

Behavioral impacts of displacement due to climate change

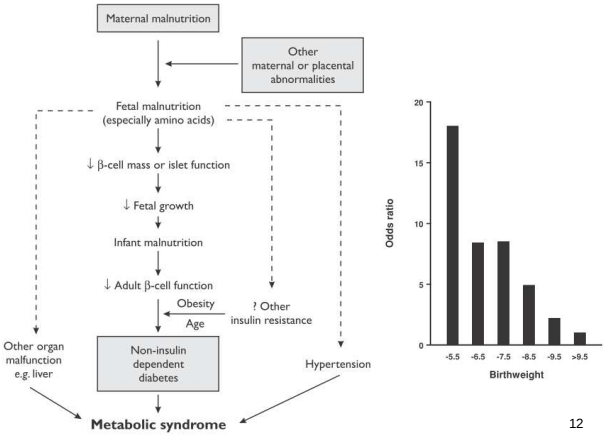
- Global: Massive population dislocation
- National: Changes to and disruption in food production and distribution
- Regional: Increased cardiovascular and respiratory disease
- Community: Functional disruption leading to scarcity of necessary resources (potable water, electricity, gas, sanitation), damage to and inaccessibility of health care facilities
- Neighborhood: Inability of neighborhood to recover, neighborhood decay, disruption of social networks
- Residential (family): Family separation, conflict, deprivation, long-term negative economic impact, educational disruption
- Individual: Dramatic increase in environmental (psychological) stress, malnutrition, loss of income, poverty, inadequate medical care

Gene-environment interaction

- Combinations of genetic susceptibility and environmental exposures account for the majority of disease burden
- As age and environmental exposure increase over time, so do the progressive molecular response and changes that are linked to the pathogenesis
- Polymorphism / variation of genetic features are related with disease susceptibility -> Human genome project (-> tailor-made medicine)
  - ELSIs (Ethical, Legal and Social Implications) are important issues. Necessity of paying attention to the potential for genetic discrimination by employers or insurers, and confidentiality issues (cf. in classic extreme, Nazi-like eugenics)
  - eg. Genetic variability and susceptibility to lead toxicity, so-called thrifty genotype/phenotype with susceptibility of obesity (phenotype is related with epigenetics), highly susceptible genotype of breast cancer, ...
  - Accelerated with the development of the "-omics" technology

The thrifty phenotype hypothesis

(Source: Br Med Bull. 2001;60:5-20. "The thrifty phenotype hypothesis." by Hales CN, Barker DJ.)



Risk Assessment / Risk Communication

- Frumkin H [Ed.] (2010) Environmental Health: From Global to Local, 2nd Ed. Chapter 29 "Risk Assessment" (by Scott Bartell) pp.1037–62, Chapter 31 "Risk Communication" (by Vincent T. Covello) pp. 1099–1140.
- 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
  - http://fshn.ifas.ufl.edu/seafood/sst/27thAnn/SP05.pdf
  - http://www.ecdc.europa.eu/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, ISBX978-4-334-03828-1

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.

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

Example of Dose-Response Assessment

- Carcinogenic effects of chloroform on male rats
  - 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, whereas the Haas (1994) estimated 0.00011 (/mg/kg/day) cancer risk added for lifetime based on 2 stage model.

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.
- 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

(cf.) 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"
- "Grey Book" (2008) ~ "Science and decisions: Advancing risk assessment" by U.S. EPA's landmark report.

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.

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 - Effects on children
    - Voluntariness - Effects on future generations
    - Controllability - Victim identity
    - Familiarity - Dread (~ fear)
    - Fairness - Media attention
    - Benefits - Accident history
    - Catastrophic potential - Reversibility
    - Understanding - Personal stake
    - Uncertainty - Ethical or moral nature
    - Delayed effects - 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, <u>Risk = Hazard + Outrage</u>**
  - **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?**
- **<u>The mental noise model</u>: Considering how people process information under the serious stress. Stress causes mental noise, then information processing is damaged.**
- **<u>The negative dominance model</u>: Considering the processing of negative and positive information in high-concern and emotionally charged situations. Negative words often dominates.**
- **<u>The trust determination model</u>: 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**
  - **<u>(template example)</u>**
    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**