4.14 Natural experiments in a hazard context

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Learning objectives

To understand the utility of natural experiments in health emergency and disaster risk management (Health EDRM) including:

- Process of conducting a natural experiment in a disaster context.
- Framework for, and outcomes of, natural experiments.
- Important strengths and limitations of natural experiments.

Natural experiments (NEs) are

Observational studies

- Participants are exposed to an intervention of interest by chance (as if at random)
- The researcher has no control over the exposure and intervention

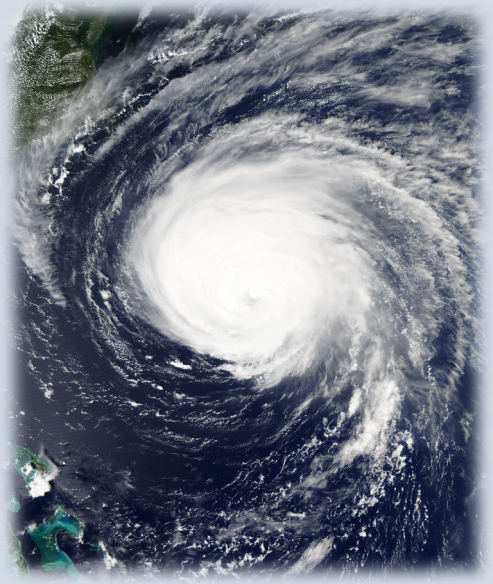
Randomized controlled trials (RCTs)

- The experimenter randomly assigns participants into intervention and control groups and determines the amount or level of intervention given.

When can NEs be applied?

Examples of situations:

- Regions affected versus not affected by a disaster (e.g., a hurricane passes through one village but not its neighboring village (Case Study 4.14.1)).
- Geological divide with distinct mineral compositions which can lead to varying levels of health risk for people on either side of the geographical boundary (Case Study 4.14.3).



Why not use the classical randomized trial design?

A typical randomized trial may not be feasible because the exposure or intervention being studied is often a health hazard or disaster in the Health EDRM context.

It would not be possible or ethical to have an experimenter who can
1) randomly assign people to either receive or not receive the intervention, and
2) control the participant's extent or level of exposure to the intervention

Framework for NE

Exposure/intervention: Exposure broadly refers to any factors (biological, behavioral, environmental) that are being studied in relation to an outcome of interest. In NEs, exposures are often disasters caused by natural or human-instigated hazards that are typically outside the researcher's control (e.g., earthquakes, conflicts).

Outcome of interest: In NEs, the effects of natural and anthropogenic hazards can be studied as outcome variables. For example, the risk of cancer (outcome) can be studied among people exposed to radiation as a result of breach in a nuclear power plant.

Framework for NE

Intervention group: The intervention group consists of people who receive the experimental intervention. In NEs, these groups are exposed to disasters or hazards not by design or deliberate random assignment, but by chance. The intervention unit may be individuals or clusters of people.

Control group: The control or comparison group serves as a reference group in an experiment. In NEs, the control group may be exposed to a hazard but to a lesser extent than the exposed (intervention) group, because there may be a range of exposure types or concentrations.

Framework for NE

Confounding factors: The exposure-outcome relationship can be influenced by factors that are associated with (or common causes of) both the exposure and the outcome.

The presence and effects of confounding factors need to be carefully checked and considered when analyzing causal relationships because they can influence the internal validity of any causal inference argument.

Case study 4.14.1: *Children's vulnerability to weather shocks (1)*

NE study looking at the impact of Hurricane Mitch (Nicaragua, October 1998) on children's wellbeing outcomes.

Exposure/intervention: Hurricane Mitch
Exposed group: Households in villages hit by the hurricane
Control group: Households in villages that were not hit
Outcomes studied: Child labor, undernourishment and access to health care

Case study 4.14.1: *Children's vulnerability to weather shocks (2)*

Was exposure by chance?
Did the villages in close proximity have similar probability of being in the path of the hurricane?

Validity of the NE design: analyzed using both quantitative and qualitative evidence

- **Quantitative:** analysis of socio-demographic differences, rural/urban area differences
- **Qualitative:** analysis of disruption in supply of social and health services due to the hurricane

Validity of NE design

Important to establish plausibility of "as if" random assignment using both:

- **Quantitative evidence:** to assess similarities between the exposed and control groups before the occurrence of the disaster or hazard.
- **Qualitative evidence:** for knowledge about the situation, context and process around how a population is exposed to the disaster or hazard.

Case study 4.14.3: *Endemic goiter prevalence in Karakoram mountains (1)*

Karakoram mountains, north Pakistan, are situated on a subducting plate, making the mineral deposits distinct on the two sides of the tectonic boundary.

Higher prevalence of visible goiter was recorded in villages situated north of the boundary than those south of it before the iodization program.

Case study 4.14.3: *Endemic goiter prevalence in Karakoram mountains (2)*

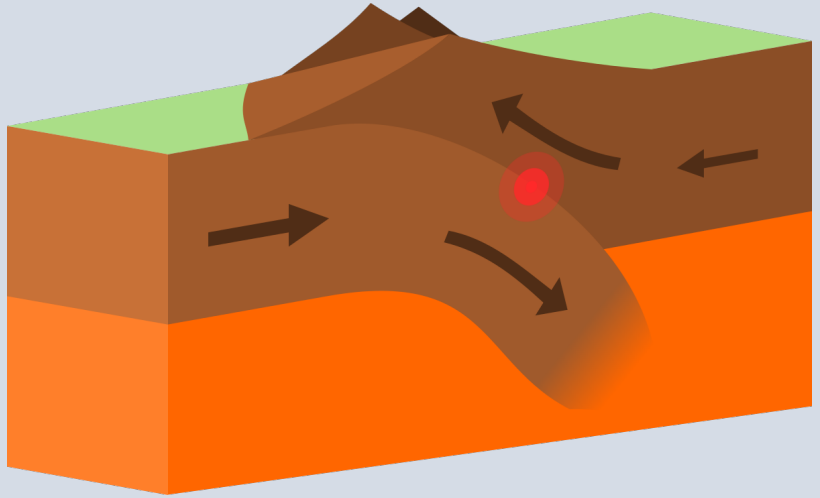
Exposure/intervention: Geology/mineral composition

Instrument: Geographical divide – being on either side of the Main Karakoram Thrust

Intervention group: Villagers north of the Karakoram Thrust

Control group: Villagers south of the Thrust

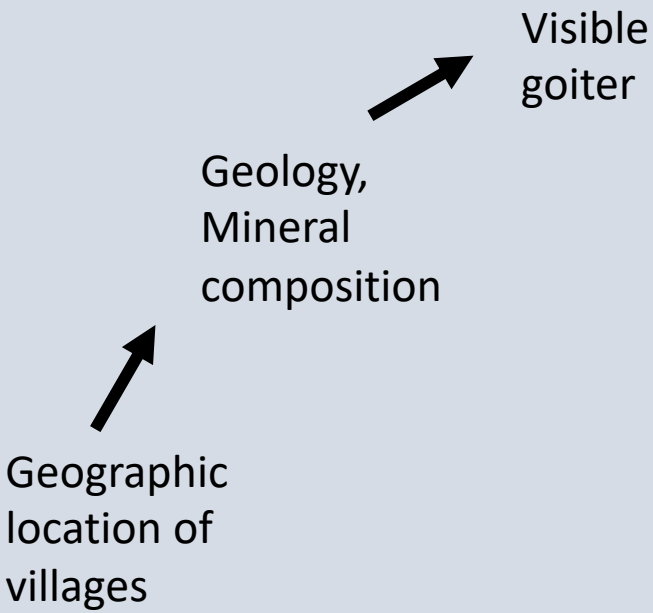
Outcome measured: Prevalence of visible goiter



Case study 4.14.3: *Endemic goiter prevalence in Karakoram mountains (3)*

Validation of NE design:

- Is the argument of exposure as if at random credible?
- The geographic location of villages was used as an instrumental variable: neighboring villages north and south of the boundary had no reason to be different other than which side of the thrust they were on.
- The geographic location itself did not independently influence the outcome but only through its association with geology and mineral composition of the area.



Case study 4.14.3: *Endemic goiter prevalence in Karakoram mountains (4)*

Validation of NE design:

- **Quantitative evidence:** study of underlying demographic characteristics did not reveal any differences between villagers north and south of the boundary.
- **Qualitative evidence:** careful qualitative investigation of communities on both sides of the thrust did not show any north-south differences in ethnicity, diet, farming practices or other obvious causes of difference.

The local population was culturally, socially and linguistically similar north-south of the thrust.

Case study 4.14.3: *Endemic goiter prevalence in Karakoram mountains (5)*

Analyses of outcome:

- Overall difference in risk between villagers north and south (95% CI for the estimated relative risk for south to north: 0.45 and 0.55)
- Difference in risk stratified by age group and sex: across the same sex and age groups, excess risk in north consistently around 15 to 18%
- Iodide concentration in water samples taken from the area showed no difference between north-south, ruling out iodine deficiency as a potential explanation for the regional difference in risk
- Results suggest that the proposed hypothesis of presence of known geological goitrogen is more plausible

Analysis of NE results

- If there is a strong case for "as if random" :
  - Analyze like a randomized trial (e.g., application of Neyman-Rubin potential outcomes model)

- If the "as if random" argument is not compelling or exposure-outcome relationship is influenced by confounding factors:
  - Analyze like other observational studies with adjustment for confounding factors

Strengths and limitations of NE design

Strengths

- Ethically more acceptable
- Can be feasible when RCT is not
- May be less affected by confounding factors
- Quantitative analysis is often simpler and more interpretable than for other observational designs
- May be more cost effective than randomized trials or quasi-experimental studies
- Ecological validity

Limitations

- No control over baseline differences between the study groups
- No random assignment in a traditional sense
- Exposure may not be of research interest or relevance
- May be difficult to contain or isolate exposure/intervention within certain perimeters
- Internal and external validity may be difficult to analyse

Key messages

- In natural or human-instigated hazard contexts, implementing the traditional experimental design to study cause-effect relationships may not be feasible or ethical.
- When people are assigned to exposure and control groups by chance, in a way that resembles true randomization, then natural experiments can be used to infer relationships between exposures and outcomes, as in a traditional experiment.

Key messages

- The credibility and validity of natural experiments depend on the persuasiveness of the "as if random" argument. Randomization would ensure that the exposed and control groups are similar in their pre-exposure characteristics and hence mitigates the effects of observed and unobserved confounding factors.

- Quantitative analyses of pre-exposure characteristics and qualitative evidence around context and processes are useful for establishing the credibility of natural experiment design.

Further readings

Craig P, Cooper C, Gunnell D, Hawk S, Lawson K, Macintyre S, et al. (2012) Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. Journal of Epidemiology and Community Health; 2012:66:1182-6

This article provides a concise outline of key issues related to conducting natural experiments and how to address some of the challenges in measuring population characteristics associated with exposures and outcomes. Recommendations for good practice in design and reporting are also provided.

Dunning T. (2012) Natural experiments in the social sciences: A design-based approach. Cambridge, United Kingdom: Cambridge University Press; 2012

A methodology book that provides comprehensive guidelines around how to assess credibility and validity of natural experiments and introduces good and bad examples of natural experiment designs.

References

This chapter: Kim, HM, Steward AG, Schluter PJ. Chapter 4.14: Natural experiments in a hazard context.
Natural experiments: Medical Research Council; www.mrc.ac.uk/naturalexperimentsguidance
RCT design elements and NE components: Essential epidemiology introduction students and health professionals 4th edition | Epidemiology, public health and medical statistics | Cambridge University Press
Hurricane Mitch case study: Children's Vulnerability to Weather Shocks: A Natural Disaster as a Natural Experiment | ALNAP
Karakoram mountains case study: BMJ 1990;300:1507-12
Statistical analysis: Annual Review of Public Health 2017;38:39-56
Neyman-Rubin outcomes model: Journal of the American Statistical Association 2005;100:322-31
Validation: Natural experiments social sciences design based approach | Qualitative methods | Cambridge University Press
More examples of NE: International Journal of Social Research Methodology 2019;22:19-35

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