STUDYING THE HEALTH IMPACTS OF ACTIVE TRANSPORTATION PROJECTS: METHODS

NATURAL EXPERIMENTS

Natural experiments like Before/After studies show the impact of an event, policy, or project as it is implemented in a real-world setting. This method is used in settings where a more controlled experiment is not possible, and the project of interest is considered the intervention. Baseline measures are taken before the intervention, and then again after a sufficient amount of time for change to theoretically be observed. Because there are so many potential environmental confounders that it can be difficult to identify what change or lack of change is attributable to the intervention. It is important to control for as many variables as possible by doing things like 1) collecting data at the same time each year, 2) developing a consistent protocol for researchers or participants to record data, and 3) using a cohort sample or matching.[1]

STUDY TYPE

COHORT or panel studies follow one sample of participants across multiple collection times. Using one sample reduces the potential for subjects as confounders. It is more difficult to maintain participants for longer periods of time, meaning that sample size can be a concern. Sample size is important because the reliability (power) of statistical analysis increases as number of observations increases.[2]

VS

CROSS-SECTIONAL studies sample from the same population across multiple collection times, but use different samples of participants. Maintaining a large sample size easier because the burden on participants is lower. However, changes in data between collection times could be due to differences in the subjects. One way to control for this is by 'matching' participants from each collection time based on demographic traits, and comparing these matched pairs.

CHALLENGES

SELECTION BIAS[3]

EXCLUSION BIAS occurs when a portion of the population is not represented in the sample. If a cohort study is done with residents of all ages, but they must be able to walk, elderly residents might be unduly excluded due to disability. Studies should be designed to minimize exclusion where possible, but it can be unavoidable. In this case, no conclusions can be made for the excluded group and a separate study should be considered.

ATTRITION BIAS is possible if subjects leave the study for a reason related to the intervention. Loss of subjects in a study is normal, but needs to be monitored for trends. When attrition is skewed, researchers must establish if the intervention is harming or underserving that group.

SELF-SELECTION BIAS occurs when a subject volunteers for a survey because of some strong connection to the topic. If the sample is weighted with this type of subject, it no longer represents the population being studied. Self-selection is expected in environmental studies, as active stakeholders will be more responsive to recruiting. This is addressed by asking self-selection questions, which measure the extent of a participant's predispositions.

INFORMATION BIAS

SURVEILLANCE BIAS is when measurements are altered by the act of being measured. This includes differences in reporting between an actively monitored sample and the population—for example, cycling accidents might be recorded at higher rates at an intersection with better monitoring, making it seem less safe. Surveillance bias also occurs when subjects change behaviour as a result of participation, as has been shown to happen with people who monitor themselves through trip diaries and similar logs.[4]

REPORTING BIAS occurs when subjects under- or misreport information due to attitudes, beliefs or perceptions. Recruitment and self-selection play a role in reporting bias if proponents of walking avoid reporting driving. Or, if the wording of a survey biases subjects towards walking, they may underreport other modes to produce favorable results. Reporting bias can be reduced through careful recruiting and survey tools designed with neutral language.

CONFOUNDING, INTERACTION, AND ASSOCIATION

CONFOUNDING variables are those in between the dependent variable—what we expect to see a change in—and the independent variable—the intervention that should cause change. Confounders are related to the independent variable but not caused by it, and are the cause of changes in the dependent variable. There are many potential confounders between active transportation facilities and health outcomes.

INTERACTION is when two variables combined have a different effect than they would separately (either increased or decreased). For example, walkability is related to safety from crime and safety from traffic, but a lack of both types of safety might have a compound effect.

ASSOCIATIONS are made with the results of collection, and the goal of any study is to establish the relationship between the dependent and independent variables. Associations can be based on variance, causal claims, and measures of risk or significance among others. It is difficult to make causal associations in natural experiments because of interactions and confounders.

1) Medical Research Council (2012). "Using natural experiments to evaluate population health interventions." Access at: http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC008043. **2)** Statistics Canada (2011). "Sampling Error: Sample Size." Access at: http://www.statcan.gc.ca/edu/power-pouvoir/ch6/sampling-echantillonage/5214807-eng.htm#a2. **3)** M Delgado-Rodriguez, J Llorca (2004). "Bias," Journal of Epidemiology and Community Health 58:635. **4)** L Reid, C Hunter, P Sutton (2011). "Rising to the challenge of environmental behaviour change: Developing a reflexive diary approach," Geoforum 42:720. **5)** Canadian Institute for Health Information (2012). "Health Indicators" and "Outcomes." Access at http://www.cihi.ca/CIHI-ext-portal/internet/EN/TabbedContent/health+system+performance/indicators/health/cihi010654 and http://www.cihi.ca/CIHI-ext-portal/internet/EN/TabbedContent/health+system+performance/quality+of+care+and+outcomes/outcomes/cihi010651.

STUDYING THE HEALTH IMPACTS OF ACTIVE TRANSPORTATION PROJECTS: MEASURES

MEASURING HEALTH

It is important to define what impacts can reasonably be observed. In health research, you can look at health indicators or outcomes. Indicators are behaviors, signs or symptoms that have been linked to a health outcome. These can be individual or environmental, such as volume of cyclists. Outcomes are diagnoses—confirmed occurrences of ill or good health measured as recovery, morbidity (sickness) or mortality (death).[5] For example, high resting heart rate is an indicator for developing ischemic heart disease, and heart disease itself is an outcome. Observations must be 1) measurable: able to be measured at a level where significant changes would be observed if they occur, 2) reliable: precise in measuring the same thing each time, and 3) valid: accurate in measuring what it is intended to. In natural experiments, it is usually more feasible to measure and observe results from indicators. It is important to distinguish between claims that subjects are healthier—outcomes were impacted—versus engaging in healthier behaviors—indicators were impacted.

SAFETY in active transportation considers both safety from traffic and safety from crime, both potential barriers to uptake.

Indicators
- Collision rates
- Crime rates
- Graffiti, vandalism, and other signs of disrepair
- Perception of safety

Outcomes
- Injury
- Mortality

HEALTH is difficult to define in a measurable way. Instead, it is common to measure disease or unhealthy (risk) behaviors, though self-rated health is a positive measure.

Indicators
- Intensity of risk behaviors such as smoking, drinking, drug use
- Uptake of healthy behaviors in diet, physical activity, stress management, etc.

Outcomes
- Disease or mental illness incidence (new diagnoses) and prevalence (total diagnoses)
- Self-rated health
- Self-rated mental health
- Chronic disease mortality

EXPOSURE to harmful emissions and noise impact respiratory, cardiovascular and mental health. Active transportation facilities can shape exposure levels for travelers and the community at large.

Indicators
- Per capita emissions of air pollutants (CO, VOC, NOx, particulates, etc.)
- Pollutant exposure levels based on pedestrian and biker respiratory rates.
- Average outdoor noise levels
- Individual sleep patterns or reported sleep disturbance

Outcomes
- Incidence of respiratory illness or acute attacks
- Self-rated respiratory health
- Mortality related to acute respiratory attacks
- Incidence of mental health diagnoses, like depression or sleep disorders
- Self-rated mental health

PHYSICAL FITNESS is the predominant health indicator in reference to active transportation. Like health, it is measured positively and negatively because active and sedentary behavior have distinct health impacts.

Indicators
- Kilometers of biking/walking routes or green space
- Transportation mode shares
- Rates or volumes of pedestrians and cyclists
- Rates of women and children pedestrians and cyclists
- Amount (time/distance) and intensity of physical activity
- Time spent inactive per week
- Hours of TV, driving, or computer use per week

Outcomes
- Resting heart rate
- Population Body Mass Index
- Body composition or muscle mass
- Self-rated fitness

TOOLS

QUESTIONNAIRES and **INTERVIEWS** are basic assessment tools. They can be a part of a larger methodology, or standalone. Questionnaires give options—open or closed questions, short or long forms. A questionnaire can be implemented after an extensive recruitment and consent process, or on the street with random volunteers. It is important that all research tools be designed carefully so that they collect the necessary information and do not create bias. Because questionnaires are so commonly used, validated surveys are available for topics like fitness and walkability, and are designed to work with minimal modification across varied contexts.[6,7]

A **TRIP DIARY**, or travel diary, provides detailed data on travel patterns. Subjects record each trip from one address to another, reporting time, locations, purpose of travel, and travel modes.[8] These form the basis for understanding participants' travel behavior. Based on study aim, additional information can be collected on topics like route choice, social interactions, and food purchasing and consumption. Travel diaries are normally recorded over 1-3 days, but can be used over weeks. Technologies like GPS, pedometers, accelerometers, or smart phones can serve as additions or alternatives to a trip diary. They can be used to verify participants' data or to add precision.

SECONDARY DATA, such as surveillance and monitoring data can be useful alone or in comparison with original data. ICBC collision records are routinely used to discuss safety from traffic, Metro Vancouver monitors emissions, and Population Data BC is a resource for a wide array of health data.[9]

HEALTH IMPACT ASSESSMENT (HIA) and **PROGRAM EVALUATION** are also useful for internal purposes or non-academic publication. Both processes are designed to produce actionable results, and the Canadian Government provides useful guidelines for development.[10,11]

6) The IPAQ Group (2012). "International Physical Activity Questionnaire." Access at https://sites.google.com/site/theipaq/home. **7)** Active Living Research (2012). "Neighborhood Environment Walkability Survey." Access at http://www.activelivingresearch.org/node/10649. **8)** P Bonnel (2009). "The Travel Survey Tool Kit: Where to from here?" Transport Survey Methods, p. 15. Access at: http://books.google.ca/books?id=P320K3je9o4C&printsec=frontcover#v=onepage&q&f=false. **9)** Insurance Corporation of BC (2012). "Statistics and Facts." Access at http://www.icbc.com/about-ICBC/news_room/icbc_facts. **10)** Health Canada (2004). "The Canadian Handbook of Health Impact Assessment." Access at http://www.hc-sc.gc.ca/fniah-spnia/pubs/promotion/_environ/handbook-guide2004/index-eng.php. **11)** Public Health Agency of Canada (2011). "Program Evaluation Tool Kit." Access at http://www.phac-aspc.gc.ca/about_apropos/evaluation/resources-eng.php.