Science, epidemiology and progress

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Objectives

• Also to pick up on a couple of important epidemiological concepts we have missed so far.
• To understand the philosophy of science and how it relates to epidemiological study design.
Epidemiological tidy up...

- Risk difference
  - Chapter 6: Pocket Guide to Epidemiology, Kleinbaum
  - “Excess risk of exposure on risk of outcome”

- Population attributable risk
  - Chapter 6: Pocket Guide to Epidemiology, Kleinbaum
Risk difference

• Cohort study of smokers after MI – 5 year CI of death – exposure (Quit or continue to smoke)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Exposure</th>
<th>Smoke</th>
<th>Quit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td></td>
<td>27</td>
<td>14</td>
<td>41</td>
</tr>
<tr>
<td>Survival</td>
<td></td>
<td>48</td>
<td>67</td>
<td>115</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>75</td>
<td>81</td>
<td>156</td>
</tr>
</tbody>
</table>

Risk (Smokers) 0.36
Risk (Quit) 0.17
Overall risk 0.26
RR 2.08
RD
RD
NNT
PPAR
Risk difference

Risk of outcome

Risk Difference (Attributable Risk)

Additional Risk from exposure

Baseline Risk - Unexposed

Prob. that exposed person develops D because of added influence of exposure
• What is effect of exposure on disease in population?

• Rare exposure with high RR may be more hazardous than common exposure with low RR

• PPAR= Overall risk – risk among unexposed

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Overall risk
PPAR = \frac{\text{prevalence}_{\text{exposure}}(RR - 1)}{1 + \text{prevalence}_{\text{exposure}}(RR - 1)}
Population attributable risk

![Graph showing the relationship between prevalence of exposure and population attributable risk. The x-axis represents the prevalence of exposure ranging from 0.00 to 1.00, while the y-axis represents population attributable risk ranging from 0.00 to 60.00. The graph illustrates an upward trend, indicating that as the prevalence of exposure increases, the population attributable risk also increases.]
Causation
Positivism and Epidemiology

• Roots in Western philosophy
• Idea to “enlighten the masses”
• Human reason as a vehicle to combat ignorance, superstition, and tyranny.
• Assumptions
  – Determinism (predict outcomes from scientific laws)
  – Objectivity (Researcher separate from participants)
  – Quantification (Information derived from measurement)
  – Reliability (extrapolation of findings to other populations)
  – Generalisability (“laws” that apply to different settings)
Causation in epidemiology

• “If the subject of epidemiologic inquiry is ... the occurrence of disease and other health outcomes ... [therefore] the ultimate goal of most epidemiologic research is the elaboration of causes that can explain patterns of disease occurrence”.

  – Rothman and Greenland.
Scientific Reasoning

• “Science is built of facts the way a house is built of bricks; but an accumulation of facts is no more science than a pile of bricks is a house”
  – Henri Poincaré
Scientific Inference

• No agreement about rules
• Inference based on logic
  – Hypotheses can not be proved, only disproved
  – Popper: method of conjecture and refutation
  – Hauck: relation of theory and data a crossword puzzle.
## Fundamental problem of causal inference

<table>
<thead>
<tr>
<th>Exposed?</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Observable</td>
</tr>
<tr>
<td>(No)</td>
<td>Counterfactual</td>
</tr>
<tr>
<td>No</td>
<td>Counterfactual</td>
</tr>
<tr>
<td>(Yes)</td>
<td>Observable</td>
</tr>
</tbody>
</table>
Induction vs Deduction

**Induction**

- Observations of nature, do they fall into a pattern?
- Assumes that what has happened in the past will continue to happen
- Switch controls light but does rooster control sun? (co-occurrence)
- Eg. vit D levels low over winter & CVD death higher? Causal relationship.

**Deduction**

- Prediction made and tested experimentally
- Limited set of observations
- Mathematical
- Needs hypotheses from induction
- E.g. RCT of effect of vitamin D on CVD events.
Bradford-Hill Criteria

- Strength
- Consistency
- Specificity
- Temporality
- Biologic gradient

- Experimental evidence
- Analogy
- Plausibility
- Coherence
Study types

**Descriptive**
- Describe what disease occurs (e.g. New Zealand Health survey)

**Analytic**
- Observational
  - Case control or cohort
  - Explain why disease occurs (e.g. British doctors study).
- Randomised controlled Trial
  - E.g. Effect of HRT on CVD.
Toxic shock

Chemical vs Toxin
How would you test?
Refutation

• Observations support a hypothesis but do not prove it.
• A single contrary observation can do away with thousands of “supporting” observations.
• Form a new hypothesis in light of refuted old hypothesis.
• “Refutation and conjecture”
• All knowledge is tentative.
• Predictions tested based on creative competing hypotheses.
Generalisation

• Not a statistical method, but a scientific method
• Does not involve inference from a sample to its source population, but abstraction into a scientific hypothesis
• Studies are stronger if subjects are more homogeneous, rather than “representative”
Can positive hypotheses be proven?

• Most studies start with Positive hypotheses
  – e.g. Smoking causes lung cancer

• Impossible to prove absence; only unlikely beyond a given strength

• Statistical analyses
  – ‘Null’ hypothesis refuted (unlikely smoking does not cause lung cancer)

• Positive hypotheses only supported, not refuted (Absence refuted).
Consensus?

• “pure” refutationist research difficult
• Findings evaluated in light of other studies and broader opinion.
• Evidenced-based practice
Summary of Scientific process

Idea
Generate hypothesis (Inductive)

Experiment
Test hypothesis (Refutation)

Interpret
Inferences from experiment (Inductive)

New Idea
Refine hypothesis (Refutation)
Summary

• Principles
  – Induction (observed co-occurrence $\rightarrow$ cause and effect)
  – Refutation (hypothesis; then predictions made and experimentally tested)

• Epi limitations
  – Few ‘clean’ experiments
  – Observations – limited experimentation
  – Inductivism assesses causation

• Solutions
  – Causal criteria (BH)
  – Consensus