THE BRADFORD HILL CRITERIA

A correlation between *X* and *Y* does not imply that *X* causes *Y*. But when *is* it reasonable to conclude that *X* causes *Y*? In ***epidemiology*** and ***law***, the Bradford Hill criteria can help us assess the issue.

WARNING: With the exception of 3, none of the criteria are *necessary* for justifying that *X* causes *Y*. Nor are the criteria *sufficient*. Ultimately, as Susan Haack says, the plausibility of someone's causal hypothesis "depends in part on how tightly the components of the whole body of their [theory] interlock, and in part on how much of the relevant information it includes" (p. 263). Bradford Hill also stresses that there is no clear algorithm for detecting cause and effect. The best we can do is go with the most justified theory, relative to the current state of evidence.

The Criteria

If there is evidence of a positive association between *X* and *Y*, then the following count as evidence that *X* causes *Y*:

1. **Strength of association**: A strong association is observed between *X* and *Y*. But note that *X* and *Y* could be causally related even if they are not strongly associated. (Few people exposed to rat urine develop Weil's disease, but the association is still causal.)
2. **Reproducibility**: A similar strength of association between *X* and *Y* is observed in a variety of different studies (e.g., in different places, with different samples).
3. **Temporality**: *X* occurs before *Y*.
4. **Dose-dependence** (epidemiology): A greater incidence of *X* usually leads to a higher incidence of *Y* (e.g., the greater the exposure to ionizing radiation, the higher the risk of malignancy). [J.S. Mill observed that this generalizes beyond epidemiology; he called it "concomitant variation" between the two variables.]
5. **Experiment**: Testing reveals that if *X* is decreased or absent, *Y* is reduced as well (e.g., social distancing is correlated with a decrease in COVID-19 cases)
6. **Specificity**: A strong association between *X* and *Y* is observed when localized to a particular, time, place, population, etc. (e.g., there is an increase in leukemia cases in a small town after a chemical factory is built nearby). High specificity suggests a lower chance that the association is mere coincidence.
7. **Analogy**: *X* and *Y* are similar to *W* and *Z*, respectively, and there is strong evidence that *W* causes *Z* (e.g., when one class of medication is known to produce an effect, another agent of that class likely produces a similar effect).
8. **Coherence**: The causal hypothesis fits with previously established facts (This criterion is not met, e.g., if a study finds higher rates of lung cancer in men while there is no antecedent biological data to support it).
9. **Biologic plausibility**: A causal relationship between *X* and *Y* is plausibly explained by known biological mechanisms (e.g., DNA damage from cigarette smoke causes cancer in the lung).