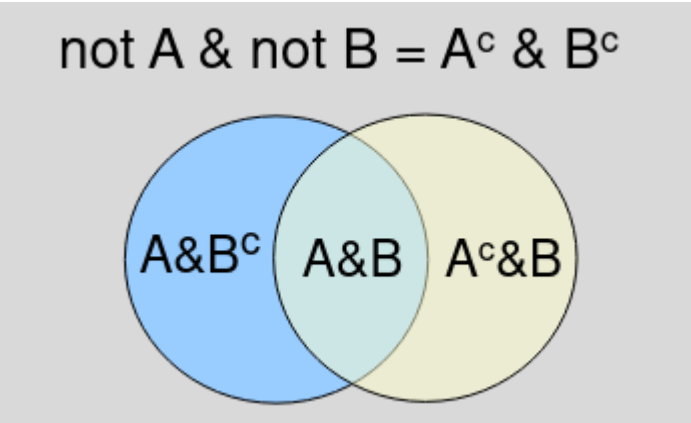
Module 2: Probability

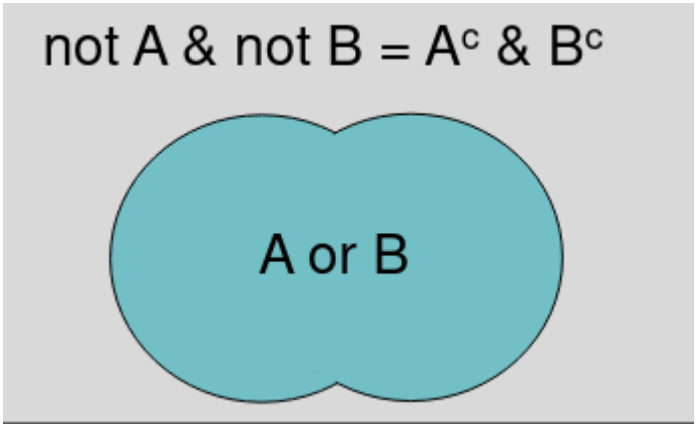
Probability is the study of uncertainty and randomness in the world. It measures chance.

Proportion is a summary statistic. Proportion measures size (i.e. how many patients have optional blood pressure).

- We show the probability of Event A as P(A)
- The compliment of an event, or chance of event not occurring is A^C
  - $P(A) + P(A^C) = 1$
- Two events are mutually exclusive (or "disjoint") if when one event occurs the other cannot
- Two events are independent if the probability of one has no impact on the occurrence of the other
  - Events are independent if:
    - P(A|B) = P(A)
    - P(A|B) = P(A| not B)
    - Odds ratio = 1 (binary outcome)
- If two events are not independent they are said to be statistically associated
- Joint Probability = P(A & B) = P(A,B) = P(A ∩ B)
  - If A and B are independent events: P(A & B) = P(A) * P(B)



- P(A or B) = P(A U B)
  - When A and B are non-mutually exclusive P(A or B) = P(A) + P(B) - P(A & B)
  - When A and B are mutually exclusive events P(A or B) = P(A) + P(B) since P(A&B)=0



- Conditional probability is the chance of an event occurring given that another event occurred, written as P(A|B) = The probability of A given B.
  - P(A|B) = P(A&B)/P(B)
  - P(A|B) * P(B) = P(A & B)

Bayes' Theorem

Because P(A & B) = P(B & A),
P(A & B) = P(B & A) = P(B|A) × P(A)
=
P(A|B) × P(B) = P(B|A) × P(A)

P(B|A) = P(A|B) * P(B) / P(A)

Sensitivity

Sensitivity of a screening test = Probability of positive test given the person has the disease. If X is the test result and Y represents if the person actually has the disease, this can be expressed as P(X = +| Y = +) = the probability of a disease given the test was positive.

Sensitivity = True Positive Fraction = P(Test+ | Disease)

Specificity = True Negative Fraction = P(Test - | No Disease)

False Positive = P(Test + | No Disease)

False negative = P(Test - | Disease)

Positive Predictive Value = P(Disease | Test +)

Negative Predictive Value = P(No Disease | Test -)

Odds Ratio

Odds ratio can be used to check independence, events are independent when OR=1.

OR = (P(X = +| Y = +) / P(X = -| Y = +)) / (P(X = +| Y = -) / P(X = -| Y = -))

= (P(X = +| Y = +) * P(X = -| Y = -)) / (P(X = +| Y = -) * P(X = -| Y = +))

Symmetry of Odds Ratio

$$OR = \frac{P(D \mid E)}{P(\text{not } D \mid E)} \div \frac{P(D \mid \text{not } E)}{P(\text{not } D \mid \text{not } E)} = \frac{P(E \mid D)}{P(\text{not } E \mid D)} \div \frac{P(E \mid \text{not } D)}{P(\text{not } E \mid \text{not } D)}$$

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