- *Addition Rule and Generalized Addition Rule*:

$P(A \cup B) = P(A) + P(B) - P(A \cap B)$

$$P(\bigcup_{i=1}^{n} E_i) = \sum_{i=1}^{n} P(E_i) - \sum_{\substack{i \\ 1\le i<j\le n}} \sum_{j} P(E_i \cap E_j) + \sum_{\substack{i \\ 1\le i<j<k\le n}} \sum_{j} \sum_{k} P(E_i \cap E_j \cap E_k) + \ldots + (-1)^{n-1} P\left(\bigcap_{i=1}^{n} E_i\right)$$

Alternatively:

$P(\bigcup_{i=1}^{n} E_i) = 1 - P(\bigcap_{i=1}^{n} E_i^c)$

Product Rule:

$P(A \cap B) = P(A|B)P(B) = P(B|A)P(A)$

$P(E_1 \cap E_2 \cap \ldots E_k) = P(E_1)P(E_2|E_1)\ldots P(E_k|E_1 \cap E_2 \cap \ldots E_{k-1})$

Total Probability and Bayes Theorem:

$P(A) = \sum_{i=1}^{n} P(A|H_i)P(H_i)$ and $P(H_i|A) = \frac{P(A|H_i)P(H_i)}{\sum_{i=1}^{n} P(A|H_i)P(H_i)}$

- *Random Variables*:

Expected Value: $E(X) = \begin{cases} \sum_x x\ f(x) & \text{if } X \text{ discrete} \\ \int_x x\ f(x)dx & \text{if } X \text{ continuous} \end{cases}$

$E(g(X)) = \begin{cases} \sum_x g(x)f(x) & \text{if } X \text{ discrete} \\ \int_x g(x)f(x)dx & \text{if } X \text{ continuous} \end{cases}$

$E(aX + b) = aE(X) + b$ and $E(X + Y) = E(X) + E(Y)$

Median: $F(\delta) = P(X \le \delta) \ge \frac{1}{2} \ge P(X < \delta) = F(\delta^-)$

p-Percentile: $F(x_p^-) = P(X < x_p) \le p \le P(X \le x_p) = F(x_p)$

Variance: $Var(X) = \sigma^2 = E\left((X - \mu)^2\right) = \begin{cases} \sum_x (x-\mu)^2 \cdot f(x) & \text{if } X \text{ discrete} \\ \int_x (x-\mu)^2 \cdot f(x)dx & \text{if } X \text{ continuous} \end{cases}$

or $Var(X) = E(X^2) - [E(X)]^2$ and $Var(\alpha X + \beta) = \alpha^2 Var(X)$

Covariance: $Cov(X,Y) = E\left((X - E(X))(Y - E(Y))\right) = E(XY) - E(X)E(Y)$

$Var(\alpha X \pm \beta Y) = \alpha^2 Var(X) + \beta^2 Var(Y) \pm 2\alpha\beta Cov(X,Y)$

Correlation Coefficient: $\rho = \frac{Cov(X,Y)}{\sigma_X \sigma_Y}$

- *Sensitivity, Specificity, Prediction Values and Likelihood ratios*

$Se = TP/(TP + FN) = TP/nD$ and $Sp = TN/(TN + FP) = TN/nD^c$

$PPV = TP/(TP + FP) = TP/nT^+$ and $NPV = TN/(TN + FN) = TP/nT^-$

$LRP = \frac{Se}{1-Sp}$ and $LRN = \frac{1-Se}{Sp}$

PV with prevalence:

$PPV = \frac{Se\times Pre}{Se\times Pre + (1-Sp)\times(1-Pre)}$ and $NPV = \frac{Sp\times(1-Pre)}{Sp\times(1-Pre) + (1-Se)\times Pre}$

- Binomial $\mathcal{B}(n,p)$

  $f(x) = \left(\begin{array}{c} n \\ x \end{array} \right) p^x(1-p)^{n-x},\ x \in \{0,1,\ldots,n\}, \quad E(X) = np,\ \ Var(X) = np(1-p)$

- Poisson $\mathcal{P}(\lambda)$

  $f(x) = e^{-\lambda}\frac{\lambda^x}{x!},\ x \in \{0,1,\ldots\}, \quad E(X) = \lambda,\ \ Var(X) = \lambda$

- Exponential $\mathcal{E}(\lambda)$

  $f(x) = \begin{cases} \lambda e^{-\lambda x} & x > 0 \\ 0 & \text{otherwise} \end{cases}, \quad E(X) = \frac{1}{\lambda},\ \ Var(X) = \frac{1}{\lambda^2}$

- Normal $\mathcal{N}(\mu,\sigma)$

  $f_X(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2\sigma^2}(x-\mu)^2}$ for $-\infty < x < \infty, \quad E[X] = \mu,\ \ Var(X) = \sigma^2$