**Applied Statistics Syllabus**

**Session 2020-2021**

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**Basic Statistics**

* Introduction to Statistics:
  + Meaning of statistics
  + Scopes and limitations
  + Concepts of descriptive and inferential statistics
* Basic Concepts:
  + Data
  + Sources of data (primary and secondary)
  + Population, sample, parameter, statistic
  + Variables and types of variables (qualitative, quantitative discrete, and continuous)
  + Scales of measurements
  + Classification of variables by scales of measurements
* Producing Data:
  + Approaches to producing data
  + Concept of experimental study and non-experimental study
  + Introduction to sample survey and questionnaire
  + Concept of electronically recorded data and hospital recorded data
  + Concept of data cleaning and checking before statistical analysis
* Organization and Presentation of Data:
  + Graphical presentation for qualitative and quantitative data
  + Sorting data
  + Grouping qualitative and quantitative data
  + Construction of frequency distribution and relative frequency distribution
  + Graphical presentation of frequency distribution (histogram, frequency polygon, ogive)
* Concept of Distribution:
  + Location, scale (spread), and shape
  + Illustration with stem-and-leaf diagram
  + Descriptive measures of data
  + Measures of location
  + Measures of dispersion
  + Moments and their interrelationship
  + Measures of skewness and kurtosis
  + Three- and five-number summary
  + Box-plot and modified box-plot
* Description of Bivariate Data:
  + Bivariate frequency distribution
  + Graphical presentation of bivariate data
  + Contingency table
  + Concept of association between two variables
  + Percentage table and interpretation of cell frequencies
  + Measures of association for nominal and ordinal variables
  + Measures of association for interval or ratio variables
  + Correlation
  + Relationship between two variables: simple linear regression
  + Basic issues in inferential statistics

**Probability and Random Variables**

* Combinatorial Analysis:
  + Basic principles of counting
  + Permutations
  + Combinations
* Axioms of Probability:
  + Sample space and events
  + Axioms of probability
  + Sample spaces having equally likely outcomes
  + Probability as a measure of belief
* Conditional Probability and Independence:
  + Conditional probabilities
  + Bayes formula
  + Independent events
* Random Variables:
  + Introduction
  + Discrete random variables
  + Expectation
  + Expectation of a function of a random variable
  + Variance
  + Bernoulli and binomial random variables
  + Poisson random variable
  + Other discrete random variables (geometric, negative binomial, hypergeometric)
  + The expected value of a sum of random variables
  + Properties of the cumulative distribution function
  + Continuous random variables
  + Expectation and variance of the continuous random variable
  + Normal random variable
  + Normal approximation to the binomial distribution
  + Exponential random variables
* Jointly Distributed Random Variables:
  + Joint distribution functions
  + Independent random variables
  + Sums of independent random variables
  + Conditional distributions (discrete and continuous cases)
  + Properties of expectation
  + Expectation of sums of random variables
  + Covariance
  + Variance of sums
  + Correlations
  + Conditional expectation
  + Moment generating functions
  + Probability generating function
* Generating Function Techniques:
  + Moment generating function
  + Cumulant generating function
  + Probability generating function
  + Characteristic function
  + Finding distributions of functions of random variables
  + Change of variable technique
  + Distribution function technique
  + Moment-generating function technique
  + Probability integral transformation
  + Statistic and sampling distribution
  + Law of large numbers
  + Central limit theorem
  + The exact distribution of the sample mean
  + Chi-square distribution and its properties
  + F-distribution and its properties
  + T-distribution and its properties
  + Non-central chi-square, F, and t distributions
  + Concept of order statistics
  + Distributions of single-order statistics
  + Joint distribution of two or more order statistics
  + A brief review of some discrete distributions
  + Continuous probability distributions and their properties (uniform, normal, exponential, gamma, beta, log-normal, Cauchy)
  + Definition of the truncated distribution
  + Definition of compound and mixture distribution
  + Family of distributions: Pearsonian distribution
* Simulation and Random Number Generations:
  + Concepts of simulation and its uses in statistics
  + Random number generators (congruential generators, seeding)
  + Random variate generations (inversion method, rejection method)
  + Simulating discrete random variables
  + Simulating normal random variables (rejection with exponential envelope, Box-Muller algorithm)
  + Monte-Carlo integration (hit-and-miss method, improved Monte-Carlo integration)
  + Variance reduction techniques (antithetic sampling, importance sampling, control variates)

**Design of Experiments**

* Introduction to Design of Experiments:
  + Strategy of experimentation
  + Some typical examples of experimental design
  + Basic principles
  + Guidelines for Designing Experiments
* Experiments with a Single Factor:
  + The analysis of variance
  + Analysis of fixed effects model
  + Estimation of model parameters
  + Unbalanced data
  + Model adequacy checking
  + Regression model
  + Comparisons among treatment means
  + Graphical comparisons of means
  + Contrasts
  + Orthogonal contrasts
  + Multiple testing
  + Scheffe’s method
  + Comparing pairs of treatments means
  + Comparing treatment means with a control
  + Determining sample size
  + Operating characteristic curve
  + Specifying standard deviation increase
  + Confidence interval estimation method
  + Discovering dispersion effects
  + Regression approach to analysis of variance
  + Least squares estimation of model parameters
  + General regression significance test
* Randomized Blocks, Latin Squares, and Related Designs:
  + The randomized complete block designs (RCBD)
  + Statistical analysis of RCBD
  + Model adequacy checking
  + Estimating model parameters
  + Latin square design
  + Graeco-Latin square design
  + Balanced incomplete block design (BIBD)
  + Statistical analysis of BIBD
  + Least squares estimation of BIBD
  + Recovery of intra-block information in the BIBD
* Introduction to Factorial Designs:
  + Basic definition and principles
  + Advantage of factorials
  + Two-factor factorial design
  + Statistical analysis of fixed effects model
  + Model adequacy checking
  + Estimating model parameters
  + Choice of sample size
  + Assumption of no interaction in a two-factor model
  + General factorial design
  + Fitting response curves and surfaces
  + Blocking in a factorial design
* 2k Factorial Design:
  + Introduction
  + 22 design
  + 23 design
  + General 2k design
  + A single replicate in 2k factorial design
  + Blocking in a 2k factorial design
  + Confounding in 2k factorial design
  + Confounding in 2k factorial design in two blocks
  + Confounding in 2k factorial design in four blocks
  + Confounding in 2k factorial design in 2p blocks
  + Partial confounding
* Two-Level Fractional Factorial Designs:
  + One-half fraction of the 2k design
  + One-quarter fraction of 2k design
  + General 2k-p fractional factorial design
  + Resolution III designs
  + Resolution IV and V designs
* Three-Level and Mixed-Level Factorial and Fractional Factorial Designs:
  + 3k factorial design
  + Confounding in 3k factorial design
  + Fractional replication of 3k factorial design
  + Factorials with mixed levels
* Response Surface Methods:
  + Introduction to Response Surface Methodology
  + Method of steepest ascent
  + Analysis of second-order response surface
  + Experimental designs for fitting response surfaces
  + Mixture experiments
  + Robust designs
* Experiments with Random Factors:
  + Random effects model
  + Two-factor factorial with random factors
  + Two-factor mixed model
  + Sample size determination with random effects
  + Rules for expected mean squares
  + Approximate F tests
  + Approximate confidence intervals on variance components
  + Modified large-sample method
  + Maximum likelihood estimation of variance components
* Nested and Split-Plot Designs:
  + Two-stage nested designs
  + Statistical analysis, diagnostic checking, variance components
  + General m-staged nested design
  + Designs with both nested and factorial factors
  + Split-plot design
  + Split-plot designs with more than two factors
  + Split-split-plot design
  + Strip-split-plot design

**Sampling Theory and Design**

* Introduction:
  + Concept of sampling and related terms
  + Role of sampling theory
  + Requirements of a good sampling design
  + Steps in a sample survey
  + Probability and nonprobability sampling
  + Selection (draw-to-draw) and inclusion probability
  + Sampling weight
  + With and without replacement sampling
  + Characteristics of estimates: bias, mean square error, and variance (precision)
  + Errors in sample survey and census
  + Sample size determination: basics and complex scenarios
* Simple Random Sampling (SRS):
  + Sample selection
  + Estimation: mean, total, proportion, ratio of two quantities
  + Unbiasedness and variances/standard errors (SEs) of the estimators
  + Estimators of the SEs
  + Confidence interval (normal approximation)
  + Finite population correction
  + Estimation over subpopulation
  + Computation: inclusion probabilities and sampling weights
* Systematic Sampling:
  + Motivation, use, and challenges
  + Sample selection
  + Different estimators and their unbiasedness and variances
  + The estimator of the variances
  + Comparison with SRS
  + Sampling from a population with linear trend or periodic variation
* Stratified Random Sampling:
  + Concept, reasoning, and needs in a heterogeneous population
  + Number and formation of strata
  + Sample selection
  + Estimators (total, mean, proportion)
  + Variances of the estimators
  + Estimators for the variances
  + Different allocation techniques
  + Comparison with SRS
  + Design effect and its uses
  + Poststratification
  + Quota sampling
* Auxiliary Information in Estimation:
  + Ratio estimators (total, mean)
  + Properties: unbiasedness, variance (approximate), estimated variance, confidence interval
  + Comparison with mean per unit estimates
  + Conditions for best linear unbiased ratio estimator
  + Application in stratified sampling
  + Unbiased ratio-type estimates
  + Product estimator
  + Regression estimator: linear regression estimate and its properties under preassigned b and estimated b
  + Comparison with mean per unit estimate
  + Application in stratified sampling
  + Relative merits and demerits
* Cluster Sampling:
  + Motivation and reasoning
  + Formation and size of clusters
  + Cluster sampling with equal-sized clusters
  + Estimators and their various properties
  + Comparison with SRS and systematic sampling
  + Optimum cluster size
  + Stratification in cluster sampling: estimation and comparison with simpler sampling designs
* Special Sampling Designs:
  + Capture-recapture sampling: implementation, Peterson and Chapman estimators for population size and their variances, Hypergeometric and Multinomial models for estimating population abundance
  + Ranked set sampling: sample selection and estimation
* Probability Proportional to Size (PPS) Sampling:
  + Motivating examples
  + With replacement (WR) sampling: cumulative measure of size method and Lahiri’s method, Hansen-Hurwitz (H-H) estimator
  + Comparison with SRS
  + Optimum measure of size
  + Without replacement (WOR) sampling: challenges and solutions, initial probabilities, normalizing probabilities, inclusion probabilities and their relation with the sample size, Horvitz-Thompson (H-T) estimator
  + Different methods of PPSWOR
  + Multinomial distribution for PPSWR sampling
  + H-T estimator in case of PPSWR sampling
* Sub-sampling and Multi-stage Sampling:
  + Sub-sampling of unequal-sized clusters: different estimators and their variances
  + Two-stage sampling: design, estimators (total, mean), variances, and their unbiased estimators
  + Three-stage sampling: design, estimators (total, mean), variances and their estimators
  + General framework (two-stage and three-stage) for estimating population total
  + Different sampling designs at different stages
  + Determination of sample sizes in two and three-stage sampling
  + Optimum sampling and sub-sampling fractions
  + Use of information from a pilot survey
* Double Sampling and Repeated Sampling:
  + Concept of double sampling and its necessity
  + Application in stratified sampling, and Ratio and Regression estimators
  + Repeated sampling from the same population: sampling on two and more than two occasions
* Complex Survey:
  + Definition and challenges involved in complex surveys
  + Approaches of variance estimation (VE)
  + Replication methods for VE: random group method, balanced repeated replication (balanced half-sample replication) method, Jackknife method, and Bootstrap method
  + Implementation of replication methods in complex sampling designs
  + Post-stratification
* Non-sampling Errors:
  + Sources of errors
  + Effects of nonresponse
  + Inference on population proportion in the presence of nonresponse
  + Types of nonresponse
  + Call-backs and their effects
  + Hansen and Hurwitz's approach to nonresponse
  + Politz-Simmons adjustment for bias reduction
  + Mathematical model for errors of measurement
  + Mechanism of nonresponse
  + Imputation and its different techniques
* Special Sampling Designs:
  + Multiplicity
  + Network sampling: design and estimation (multiplicity and Horvitz-Thompson estimators for population total, and their different properties)
  + Adaptive sampling: adaptive cluster sampling (ACS) and related concepts used in ACS, Hansen-Hurwitz and Horvitz-Thompson estimators for population total, and their different properties

**Statistical Inference**

* Basic Concepts:
  + Fundamental ideas of statistical inference
  + Parametric and non-parametric inference
  + Estimators, statistics, parameters
  + Sampling distributions and their uses in inference
  + Point estimation, interval estimation, and test of hypotheses
  + Theory and reality
* Point Estimation of Parameters and Fitting of Probability Distributions:
  + Descriptive statistics
  + Exploratory data analysis
  + Least squares estimation
  + Moments based estimation
  + Maximum likelihood estimation
  + Uses of graphical tools for assessing goodness of fit
  + Asymptotic distributions of maximum likelihood estimators
* Interval Estimation:
  + Methods for constructing confidence intervals
  + Pivotal quantity method
  + Wald-type method
  + Likelihood ratio-based method
  + Confidence intervals for means, the difference of two means, proportions
  + Interpretation of confidence intervals
* Testing Hypotheses and Assessing Goodness of Fit:
  + Heuristics of hypothesis testing
  + Errors in hypothesis testing
  + Statistical significance and power
  + Exact tests and approximate tests
  + Tests about one population mean, equality of two population means, more than two population means, proportions
  + Likelihood ratio test
  + Statistical tests applied to categorical data: Fisher’s exact test, chi-square test of homogeneity and independence, chi-square goodness of fit tests
* Testing Hypotheses:
  + Approaches to hypothesis testing (Neyman-Pearson, Fisher, Jeffreys)
  + Error probabilities and the power function
  + Best test concept
  + The most powerful test via the Neyman-Pearson lemma
  + Uniformly most powerful (UMP) test via the Neyman-Pearson Lemma
  + Likelihood ratio property
  + UMP test via maximum likelihood ratio property
  + Unbiased and UMP unbiased tests
* Principle of Data Reduction:
  + Sufficiency
  + Conditional distribution approach
  + Neyman factorization theorem
  + Minimal sufficiency
  + Lehmann-Scheffe approach
  + Information in one-parameter and multi-parameter situations
  + Ancillary
  + Completeness
  + Complete sufficient statistics
  + Basu’s theorem
* Likelihood-Based Inference in Exponential Families:
  + Formulation
  + Estimation in one-parameter and multi-parameter cases
  + Approximate normality of MLEs
  + Wald tests and confidence intervals
  + Likelihood ratio test and confidence interval
  + Inference about g(θ) using the delta method applied to MLEs
* Criteria to Compare Estimators:
  + Unbiasedness, variance, mean squared error
  + Best unbiased and linear unbiased estimators
  + Improved unbiased estimator via sufficiency
  + Rao-Blackwell theorem
  + Uniformly minimum variance unbiased estimator (UMVUE)
  + Cramer-Rao inequality and UMVUE
  + Lehmann-Scheffe theorems and UMVUE
  + Generalization of the Cramer-Rao inequality
  + Evaluation of conditional expectations
  + Unbiased estimation under incompleteness
  + Consistent estimators
  + Comparison of estimators using the decision-theoretic approach (loss function, risk function)
* Statistical Inference:
  + Parametric, nonparametric, and semiparametric inference
* Approximate and Computationally Intensive Methods:
  + The general problem of inference
  + Likelihood functions
  + Maximum likelihood estimation
  + Optimization techniques (Newton-type methods)
  + EM algorithm (simple form, properties, uses in analyzing missing data, fitting mixture models and latent variable model)
  + Restricted maximum likelihood (REML) method of estimation
  + Multi-stage maximization
  + Efficient maximization via profile likelihood
  + Confidence interval and testing hypothesis in complex cases
  + Bayesian method of inference (prior and posterior distribution, different types of prior, credible intervals, testing hypothesis)
  + Analytical approximations (asymptotic theory, Laplace approximation)
  + Numerical integral methods (Newton-Cotes type methods)
  + Monte Carlo methods
  + Simulation methods (Markov chain Monte Carlo)
* Resampling Techniques:
  + Bootstrap (confidence intervals, tests, parametric bootstrap)
  + Jackknife (confidence interval, test, and permutation test)
* Nonparametric Inference and Robustness:
  + Introduction
  + Inference concerning cumulative distribution function (CDF)
  + Quantiles and statistical functionals
  + Empirical CDF
  + Estimating statistical functionals
  + Influence functions
  + Testing statistical hypothesis in one sample and two or more sample settings
  + Tolerance limit
  + Empirical density estimation (histograms, kernel, kernel density estimation)

**Multivariate Analysis**

* Preliminaries of Multivariate Analysis:
  + Applications of multivariate techniques
  + Organization of data
  + Data display and pictorial representations
  + Distance
* Random Vectors and Random Sampling:
  + Basics of matrix and vector algebra
  + Positive-definite matrices
  + Square-root matrix
  + Random vectors and matrices
  + Mean vectors and covariance matrices
  + Matrix inequalities and maximization
  + Geometry of the sample
  + Random sample and expected values of sample means and covariance matrix
  + Generalized variance
  + Sample mean, covariance, and correlation as matrix operations
  + Sample values of linear combinations of variables
* The Multivariate Normal Distribution:
  + Multivariate normal density and its properties
  + Sampling from a multivariate normal distribution and maximum likelihood estimation
  + Sampling distribution and large sample behavior of sample mean vector and sample variance-covariance matrix
  + Assessing the assumption of normality
  + Detecting outliers and data cleaning
  + Transformation to near normality
* Inferences about a Mean Vector:
  + Plausibility of mean vector as a value for a normal population mean
  + Hotelling T² and likelihood ratio tests
  + Confidence regions and simultaneous comparisons of component means
  + Large sample inference about a population mean vector
  + Inferences about mean vectors when some observations are missing
  + Time dependence in multivariate data
* Comparisons of Several Multivariate Means:
  + Paired comparisons and a repeated measures design
  + Comparing mean vectors from two populations
  + Comparison of several multivariate population means (one-way MANOVA)
  + Simultaneous confidence intervals for treatment effects
  + Two-way multivariate analysis of variance
  + Profiles analysis
  + Repeated measures designs and growth curves
* Multivariate Linear Regression Models:
  + The classical linear regression model
  + Least squares estimation
  + Inferences about the regression model
  + Inferences from the estimated regression function
  + Multivariate multiple regression
  + Comparing two formulations of the regression model
  + Multiple regression model with time-dependent errors
* Principal Components:
  + Population principal components
  + Summarizing sample variations by principal components
  + Graphing the principal components
  + Large sample inference
* Factor Analysis:
  + Orthogonal factor models
  + Methods of estimation (maximum likelihood estimates and principal factor analysis)
  + Selection of loadings and factor
  + Factor rotation
  + Varimax rotation
  + Quartimax rotation
  + Oblimin rotations
  + Factor scores
  + Structural equations models
* Canonical Correlation Analysis:
  + Canonical variates and canonical correlations
  + Sample canonical variates and sample canonical correlations
  + Large sample inference
* Discrimination and Classification:
  + Separation and classification of two populations
  + Classification of two multivariate normal populations
  + Evaluating classification functions
  + Fisher’s discriminant function
  + Classification with several populations
  + Fisher’s method for discriminating several populations
* Clustering:
  + Similarity measures
  + Hierarchical clustering methods
  + Non-hierarchical clustering methods
  + Fuzzy clustering
  + Determination of the number of clusters
  + Gap statistics and its modifications
  + Cluster validity indices
  + Cluster’s homogeneity test
  + Multidimensional scaling

**Lifetime Data Analysis**

* Basic Concepts and Models:
  + Lifetime distributions
  + Continuous models
  + Discrete models
  + General formulation
  + Important models
  + Exponential, Weibull, log-normal, log-logistic, gamma distributions
  + Log-location-scale models
  + Inverse Gaussian distribution models
  + Mixture models
  + Regression models
* Observation Schemes, Censoring, and Likelihood:
  + Right censoring and maximum likelihood
  + Other forms of incomplete data
  + Truncation and selection effects
  + Information and design issues
* Nonparametric and Graphical Procedures:
  + Nonparametric estimation of survivor function and quantiles
  + Descriptive and diagnostic plots
  + Estimation of hazard or density functions
  + Methods of truncated and interval-censored data
  + Life tables
* Inference Procedures for Parametric Models:
  + Inference procedures for exponential distributions
  + Inference procedures for gamma distributions
  + Inference procedures for inverse Gaussian distributions
  + Inference for grouped, interval-censored, or truncated data
  + Mixture models
  + Threshold parameters
  + Prediction intervals
* Inference Procedure for Log-Location-Scale Distributions:
  + Inference for location-scale distributions
  + Weibull and extreme-value distributions
  + Log-normal and log-logistic distributions
  + Comparison of distributions
  + Models with additional shape parameters
  + Planning experiments for life tests
* Parametric Regression Models:
  + Introduction to log-location-scale regression models
  + Proportional hazards regression models
  + Graphical methods and model assessment
  + Inference for log-location-scale models
  + Extensions of log-location-scale models
  + Hazard-based models
* Brief Introduction to Cox’s Proportional Hazards Model:
  + Partial likelihood function
  + Estimation and interpretation of model parameters

**Analysis of Time Series**

* Introduction and Examples of Time Series:
  + Time series plots
  + Trend
  + Seasonal effects
  + Sample autocorrelation
  + Correlogram
  + Filtering
* Probability Models:
  + Stochastic processes
  + Stationarity
  + Second-order stationarity
  + White noise model
  + Random walks
  + Moving average (MA) processes
  + Autoregressive (AR) processes
  + ARMA processes
  + Seasonal ARMA processes
  + General linear process
  + Properties, estimation, and model building
  + Diagnostic checking
* Forecasting:
  + Naive procedures
  + Exponential smoothing
  + Holt-Winters
  + Box-Jenkins forecasting
  + Linear prediction
  + Forecasting from probability models
* Non-Stationary Time Series:
  + Non-stationarity in variance
  + Logarithmic and power transformations
  + Non-stationarity in mean
  + Deterministic trends
  + Integrated time series
  + ARIMA and seasonal ARIMA models
  + Modeling seasonality and trend with ARIMA models
* Stationary Processes in the Frequency Domain:
  + Spectral density function
  + The periodogram
  + Spectral analysis
* Concept of State-Space Models:
  + Dynamic linear models
  + The Kalman filter

**Statistical Modeling and Analysis**

* Measures of Association for Quantitative Data:
  + Correlation and inference concerning correlation
  + Regression and model building
  + Motivating examples
  + Uses of regression
* Simple Linear Regression Model:
  + Model for E(Y |x)
  + Least squares estimation
  + Assumptions related to errors
  + Maximum likelihood estimation (MLE) of the model
  + Sampling distribution of MLEs of the model parameters
  + Inferences concerning the model parameters (confidence intervals and t-test)
  + Confidence interval estimate of E(Y |x) (confidence band)
  + Model accuracy and diagnostics
  + Goodness of fit test (F-test, coefficient of determination, R²)
  + Prediction and prediction interval for a new Y at a specific x
  + Residual analysis
  + Detection and treatment of outliers
  + Concept of lack of fit and pure error
  + Test for lack of fit
  + Transformations as a solution to problems with the model
  + Weighted least squares
  + Matrix representation of simple linear regression model, inference, and prediction
* Multiple Linear Regression Models:
  + Formulation of multiple regression models
  + Estimation of the model parameters
  + Least squares estimation
  + Maximum likelihood estimation
  + Sampling distributions of the MLEs
  + Confidence interval and hypothesis testing concerning model parameters
  + Model accuracy and diagnostics
  + Goodness of fit test (F-test, R², adjusted R²)
  + Prediction of a new observation
  + The extra sum of squares principles and its application in testing the general linear hypothesis
  + Checking all assumptions concerning the model and use of remedy measures when assumptions are not valid
  + Detection and treatment of outliers and influential observations
* Polynomial Regression Model:
  + Introduction
  + Polynomial models in one variable
  + Basic principles
  + Piecewise polynomial fitting
  + Polynomial models in two or more variables
  + Orthogonal polynomials
* Indicator Variables:
  + The general concept of an indicator variable
  + Use of indicator variables in linear regression
  + Models with only indicator variables
  + Regression models with an indicator response variable
* Variable Selection and Model Building:
  + Model building problem
  + Consequences of model misspecification
  + Criteria for evaluating subset regression models
  + Computational techniques for variable selection
* Validation of Regression Models:
  + Concept of cross-validation
* Generalized Linear Model:
  + Exponential family of distributions
  + Estimation methods
  + Method of maximum likelihood
  + Method of least squares
  + Inference
  + Sampling distribution for scores
  + Sampling distribution for maximum likelihood estimators
  + Confidence intervals for model parameters
  + Adequacy of a model
  + Sampling distribution for log-likelihood statistic
  + Log-likelihood ratio statistic (deviance)
  + Assessing goodness of fit
  + Hypothesis testing
  + Multiple regression
  + Maximum likelihood estimation
  + Log-likelihood ratio statistic
* Models for Binary Responses:
  + Probability distributions
  + Generalized linear models
  + Dose-response models
  + General logistic regression
  + Maximum likelihood estimation and log-likelihood ratio statistic
  + Other criteria for goodness of fit
  + Least square methods
  + Multinomial distributions
  + Nominal logistic regression models
  + Ordinal logistic regression models
* Models for Count Data, Poisson Regression, and Log-linear Models:
  + Probability distributions
  + Maximum likelihood estimation
  + Hypothesis testing and goodness of fit

**Demography**

* Basic Concepts of Demography:
  + Role and importance of demographic/population studies
  + Sources of demographic data: census, vital registration system, sample surveys, population registers, and other sources, especially in Bangladesh
* Errors in Demographic Data:
  + Types of errors
  + Methods of testing the accuracy of demographic data
  + Quality checking and adjustment of population data
  + Post Enumeration Check (PEC) and detection of errors and deficiencies in data and the needed adjustments and corrections
* Fertility:
  + Basic measures of fertility
  + Crude birth rate
  + Age-specific fertility rates (ASFR)
  + General fertility rate (GFR)
  + Total fertility rate (TFR)
  + Gross reproduction rate (GRR) and net reproduction rate (NRR)
  + Child-woman ratio
  + Concept of fecundity and its relationship with fertility
* Demographic Theory:
  + Transition theory and the present situation in Bangladesh
  + Malthus’ theory and its criticism
* Mortality:
  + Basic measures of mortality
  + Crude death rate (CDR)
  + Age-specific death rates (ASDR)
  + Infant mortality rate
  + Child mortality rate
  + Neonatal mortality rate
  + Standardized death rate, its need, and use
  + Direct and indirect standardization of rates
  + Commonly used ratios: sex ratio, child-woman ratio, dependency ratio, density of population
* Fertility and Mortality in Bangladesh Since 1951:
  + Reduction in fertility and mortality in Bangladesh in recent years
  + Role of socio-economic Development on Fertility and mortality
* Nuptiality:
  + Marriage
  + Types of marriage
  + Age of marriage
  + Age at marriage and its effect on fertility
  + Celibacy, widowhood, divorce, and separation, their effect on fertility and population growth
* Migration:
  + Definition, internal and international migration
  + Sources of migration data
  + Factors affecting both internal and international migration
  + Laws of migration
  + Impact of migration on origin and destination
  + Effect on population growth, age and sex structure, labor supply, employment and unemployment, wage levels, and other socio-economic effects
  + Migration of Bangladeshis abroad and its impact on the overall economic development of the country
* Graduation of Data:
  + Meaning and its need
  + Techniques of graduation
  + Graduation of age distribution
  + Life table: concept, structure, and calculation
  + Complete life table (life table by single year of age) and abridged life table
  + Multiple decrement life tables
  + Working life table
  + Different life table functions and inter-relationships among them
  + Use of life table
  + Model life tables
  + Coale and Demeny regional model life tables
* Force of Mortality:
  + Idea and definition
  + Calculation of life table with the help of the force of mortality
* Population Growth:
  + Techniques to measure it
  + Doubling time concept in demography
  + Population estimates and projections
  + Different techniques of population projection
  + Need for population projections
  + Use of Lee-Carter model in population projections
* Stable and Stationary Population:
  + Characteristics and uses
  + Lotka’s characteristics equation
  + Intrinsic birth and death rates
  + Effect of a uniform drop in the force of mortality on the growth rate
  + Effects of changes in fertility and mortality on the age distribution of the population
* Population in Bangladesh:
  + History of the growth of the population in Bangladesh
  + Implications of the growth of population in Bangladesh
  + Population policy in Bangladesh
  + Level, trends, and determinants in fertility, mortality, and migration in Bangladesh
  + Interrelationship between population and development
  + Prospects of population and population control in Bangladesh
  + Aged and aging of the population in Bangladesh

**Epidemiological Statistics**

* Introduction:
  + Disease processes
  + Statistical approaches to epidemiological data
  + Study design
  + Binary outcome data
  + Causality
* Measures of Disease Occurrence:
  + Prevalence and incidence
  + Disease rates
  + Hazard function
  + Review of simple random samples
  + Probability, conditional probabilities, and independence of two events
* Measures of Disease-Exposure Association:
  + Relative risk
  + Odds ratio
  + Relative hazard
  + Risk attributable risk
* Study Designs:
  + Population-based studies
  + Cohort studies
  + Case-control studies
  + Case-cohort studies
  + Assessing the significance of 2 × 2 tables obtained from cohort designs, case-control designs
* Estimation and Inference for Measures of Association:
  + Odds ratio
  + Sampling distribution
  + Confidence interval for odds ratio
  + Relative risk
  + Excess risk
  + Attributable risk
* Confounding and Interaction:
  + Causal inference
  + Counterfactuals
  + Confounding variables
  + Control of confounding variables by stratification
  + Causal graphs
  + Controlling confounding in causal graphs
  + Cochran-Mantel-Haenszel test
  + Summary estimates and confidence intervals for odds ratio and relative risk after adjusting for confounding factors
* Interaction:
  + Multiplicative and additive interaction
  + Interaction and counterfactuals
  + Test of consistency of association across strata
  + Overall test of association
  + Test for the trend in risk
* Introduction to Matching:
  + Types of matching
  + Analysis of matched studies

**Biostatistics and Statistical Methods**

* Definition, Scope, and Importance:
  + Definition and scope of statistics and biostatistics
  + Uses and importance of statistics and biostatistics
  + Limitations of using statistics and biostatistics
  + Population, sample, parameter, statistic, estimator, and estimate
* Data Presentation:
  + Meaning of data
  + Level of measurement
  + Variables (discrete and continuous)
  + Summarizing and presenting data
  + Tabular, graphical, and diagrammatic representation of data
* Descriptive Statistics:
  + Measures of central tendency (Arithmetic mean, geometric mean, harmonic mean, median, and mode)
  + Measures of dispersion (Range, mean deviation, variance, coefficient of variation, standard deviation)
  + Moments, skewness, and kurtosis
* Probability Distribution:
  + The normal, binomial, and Poisson distribution
  + Derivation, means, and variances
  + Point estimation
  + The Mean and its Standard Error
  + The Central Limit Theorem
  + Confidence Intervals (Mean of a sample, Binomial proportions)
* Hypothesis Testing:
  + General concepts
  + The basic idea of significance tests
  + Simple significance tests based on the normal distribution
  + Comparison with a known standard
  + Comparison of means of two large samples
* t-Tests:
  + The use of 't' tests for small samples
  + Importance of small sample comparison
  + Comparison of sample means with a standard
  + Comparison of means of two small samples (unknown variances-assumed equal, not assumed equal)
  + Confidence limits
  + One-sample t-test, Paired & unpaired t-tests
  + Nonparametric analogs
* Contingency Tables:
  + Comparing binomial proportions
  + X²-tests of goodness of fit and homogeneity
  + Introduction to the general idea
  + Testing the fit of a whole frequency distribution to data
  + Tests of homogeneity
  + Variance ratio test
* Correlation Coefficients:
  + Properties of ρ (rho)
  + Pearson’s correlation coefficient
  + Spearman’s ρ (rho)
  + Kendall’s τ (tau)
  + Types of Correlation (Bivariate Correlations, Partial Correlations, Distances)
* Linear Regression:
  + Introduction to Linear Regression
  + Purposes and assumptions for using the linear regression model
  + Least Squares Method
  + R² - Variance explained
* Analysis of Variance (ANOVA):
  + One-way ANOVA
  + Two-way ANOVA
* Power, Sample Size, and Effect Size:
  + Practical vs. statistical significance.