

PH.140 (BIOSTATISTICS)

PH.140.604. Introduction to R for Public Health Researchers. 2 Credits.

Provides “hands-on” training for analyzing data in the R statistical software package, a popular open-source solution for data analysis and visualization. Covers data input/output, data management and manipulation, and constructing useful and informative graphics. Geared towards individuals who have never used R or have a little familiarity. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.605. Introduction to the SAS Statistical Package. 2 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.606. Survival Analysis. 2 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.607. Multilevel Models. 2 Credits.

Gives an overview of “multilevel statistical models” and their application in public health and biomedical research. Multilevel models are regression models in which the predictor and outcome variables can occur at multiple levels of aggregation: for example, at the personal, family, neighborhood, community and regional levels. They are used to ask questions about the influence of factors at different levels and about their interactions. Multilevel models also account for clustering of outcomes and measurement error in the predictor variables. Students focus on the main ideas and on examples of multi-level models from public health research. Students learn to formulate their substantive questions in terms of a multilevel model, to fit multilevel models using Stata during laboratory sessions and to interpret the results. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.608. Analysis of Longitudinal Data. 2 Credits.

Covers statistical models for drawing scientific inferences from longitudinal data. Topics include longitudinal study design; exploring longitudinal data; linear and generalized linear regression models for correlated data, including marginal, random effects, and transition models; and handling missing data. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.609. Improving Precision and Power in Randomized Trials by Leveraging Baseline Variables. 0.5 Credits.

Explains what covariate adjustment is, how it works, when it may be useful to apply, and how to implement it (in a preplanned way that is robust to model misspecification) for a variety of scenarios. Demonstrates the impact of covariate adjustment using trial data sets in multiple disease areas. Provides step-by-step, clear documentation of how to apply the software in each setting. Applies the software tools on the different datasets in small groups. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.611. Statistical Reasoning in Public Health I. 3 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.612. Statistical Reasoning in Public Health II. 3 Credits.

Provides a broad overview of biostatistical methods and concepts used in the public health sciences, emphasizing interpretation and concepts rather than calculations or mathematical details. Develops ability to read the scientific literature to critically evaluate study designs and methods of data analysis. Introduces basic concepts of statistical inference, including hypothesis testing, p-values, and confidence intervals. Includes topics: comparisons of means and proportions; the normal distribution; regression and correlation; confounding; concepts of study design, including randomization, sample size, and power considerations; logistic regression; and an overview of some methods in survival analysis. Draws examples of the use and abuse of statistical methods from the current biomedical literature.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.613. Data Analysis Workshop I. 2 Credits.

Emphasizes concepts and illustration of concepts applying a variety of analytic techniques to public health datasets in a computer laboratory using Stata statistical software. Learns basic methods of data organization/management and simple methods for data exploration, data editing, and graphical and tabular displays. Includes additional topics: comparison of means and proportions, simple linear regression and correlation.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.614. Data Analysis Workshop II. 2 Credits.

Emphasizes concepts and illustration of concepts applying a variety of analytic techniques to public health datasets in a computer laboratory using Stata statistical software. Masters advanced methods of data analysis including analysis of variance, analysis of covariance, nonparametric methods for comparing groups, multiple linear regression, logistic regression, log-linear regression, and survival analysis.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.615. Statistics for Laboratory Scientists I. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.616. Statistics for Laboratory Scientists II. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.620. Advanced Data Analysis Workshop. 2 Credits.

Covers methods for the organization, management, exploration, and statistical inference from data derived from multivariable regression models, including linear, logistic, Poisson and Cox regression models. Students apply these concepts to two or three public health data sets in a computer laboratory setting using STATA statistical software. Topics covered include generalized linear models, product-limit (Kaplan-Meier) estimation, Cox proportional hazards model.

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PH.140.621. Statistical Methods in Public Health I. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.622. Statistical Methods in Public Health II. 4 Credits.

Presents use of confidence intervals and hypothesis tests to draw scientific statistical inferences from public health data. Introduces generalized linear models, including linear regression and logistic regression models. Develops unadjusted analyses and analyses adjusted for possible confounders. Outlines methods for model building, fitting and checking assumptions. Focuses on the accurate statement of the scientific question, appropriate choice of generalized linear model, and correct interpretation of the estimated regression coefficients and confidence intervals to address the question.

Corequisite(s): Must also register for lab, PH.140.922.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.623. Statistical Methods in Public Health III. 4 Credits.

Corequisite(s): Must also enroll for PH.140.923

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.624. Statistical Methods in Public Health IV. 4 Credits.

Builds on the concepts, methods, and computing (Stata, R) covered in Statistical Methods 1,2, and 3. Focuses on investigating scientific questions via data analysis and clearly communicating the methodology and results. Uses examples from the contemporary and public health literature and allows students the opportunity to work with their own data over the duration of the class.

Corequisite(s): Must also enrol for a lab, PH.140.924.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.628. Data Science for Public Health I. 4 Credits.

Presents the basics of data science using the R programming language. Teaches basic unix, version control, graphing and plotting techniques, creating interactive graphics, web app development, reproducible research tools and practices, resampling based statistics and artificial intelligence via deep learning, focusing on practical implementation specifically tied to computational tools and core fundamentals necessary for practical implementation. Culminates with a web app development project chosen by student (who will come out of this course sequence well-equipped to tackle many of the data science problems that they will see in their research).

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.629. Data Science for Public Health II. 4 Credits.

Presents the basics of data science using the R programming language. Teaches basic unix, version control, graphing and plotting techniques, creating interactive graphics, web app development, reproducible research tools and practices, resampling based statistics and artificial intelligence via deep learning, focusing on practical implementation specifically tied to computational tools and core fundamentals necessary for practical implementation. Culminates with a web app development project chosen by student (who will come out of this course sequence well-equipped to tackle many of the data science problems that they will see in their research).

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PH.140.630. Introduction to Data Management. 3 Credits.

Introduces students to the principles and skills required to collect and manage research data in a public health setting. Focuses on tools for collecting data that range from spreadsheets to web-based systems, database fundamentals, data collection form design, data entry screen design, proper coding of data, strategies for quality control and data cleaning, protection and sharing of data, and integrating data from external sources. Includes practical and hands-on exercises that require some entry-level computer programming.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.631. The SAS Statistical Package: A Survey for Statisticians. 3 Credits.

Introduces students to the SAS statistical package using the SAS Studio interface. Using examples of public health data students learn to write programs to summarize data and to perform statistical analyses. Using the interactive matrix language introduces computation within a matrix environment and the development of modular programming techniques. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.632. Introduction to the SAS Statistical Package. 3 Credits.

Introduces students with no experience with SAS. Familiarizes them with the skills needed for effective data management and data analysis. Covers performing exploratory analysis on data including the creation of tables and graphs. Proceeds next to creating new datasets and altering old datasets. Covers building regression models (linear, logistic, and Poisson), interpreting results and criticizing such models, and attempting to improve them.

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PH.140.633. Biostatistics in Medical Product Regulation. 2 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.634. Non-Inferiority and Equivalence Clinical Trials. 2 Credits.

Presents the important differences between superiority trials and those intended to show either equivalent effect, or to show that one therapy is no worse than another (but might be better). Explores the problems of setting equivalence margins, preservation of some proportion of active control effect, and emphasizes the use of confidence intervals to interpret the results of studies. Discusses special issues of quality of the trial conduct, assay sensitivity, historical evidence of treatment effects and assumptions of constancy of treatment effects over time. Compares sample size requirements between superiority trials, equivalence trials and non-inferiority trials. Discusses the use of different analysis populations (ITT and per-protocol) and issues of changing conclusions between non-inferiority and superiority. Discusses the regulatory aspects of trial design and interpretation, and reviews existing regulatory guidance.

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PH.140.636. Scalable Computational Bioinformatics. 4 Credits.

Introduces the computational hardware and programming model upon which analysis tools and languages are based. Introduces and uses three main languages (Python, Perl, SQL) and their underlying rationale to develop computer science concepts such as data structures, algorithms, computational complexity, regular expressions, and knowledge representation. Draws examples and exercises from high-throughput sequence analysis, proteomics and modeling of biological systems. Reinforces key concepts through lectures with live computer demonstrations, weekly readings, and programming exercises. Has students working with a High Performance Compute Cluster and the Amazon cloud.

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PH.140.638. Analysis of Biological Sequences. 3 Credits.

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PH.140.640. Statistical Methods for Sample Surveys. 3 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.641. Survival Analysis. 3 Credits.

Introduces fundamental concepts, theory and methods in survival analysis. Emphasizes statistical tools and model interpretations which are useful in medical follow-up studies and in general time-to-event studies. Includes hazard function, survival function, different types of censoring, Kaplan-Meier estimate, log-rank test and its generalization. For parametric inference, includes likelihood estimation and the exponential, Weibull, log-logistic and other relevant distributions. Discusses in detail statistical methods and theory for the proportional hazard models (Cox model), with extensions to time-dependent covariates. Includes clinical and epidemiological examples (through class presentations). Introduces basic concepts and methods for competing risks data, including the cause-specific hazard models and other models based of cumulative incidence function (CIF). Illustrates various statistical procedures (through homework assignments).

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PH.140.642. Design of Clinical Experiments. 3 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.643. Practice of Statistical Consulting. 3 Credits.

Emphasizes the understanding of, and practical experience in, the spectrum of non-technical aspects of statistical consulting, the art and science of applying statistics to real-world problems. Discusses the elements of a consultation, from defining the research problem to providing final products to the client, interpersonal communication, reproducible work, ethics and consulting in different environments. Develops students' consulting skills via lectures, role-play opportunities, consulting sessions, and actual research projects. Acquaints students with practical consulting experience through shadowing and leading the Biostatistics Center's clinics on Friday mornings. Provides opportunities to work directly with Johns Hopkins researchers to elicit information about the research question, and to provide a presentation and final report to researchers.

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PH.140.644. Statistical Machine Learning: Methods, Theory, and Applications. 4 Credits.

Introduces popular Machine Learning methods and emphasizes their practical usage for data analysis. Acquaints students with methods to evaluate statistical machine learning models defined in terms of algorithms or function approximations using basic coverage of their statistical and computational theoretical underpinnings. Topics covered include: regression and prediction, tree-based methods, overview of supervised learning theory, support vector machines, kernel methods, ensemble methods, clustering, visualization of large datasets and graphical models. Examples of method applications covered include cancer prognosis from microarray data, visualization and analysis of social network data, and graphical models for clinical decision-making. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.646. Essentials of Probability and Statistical Inference I: Probability. 4 Credits.

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PH.140.647. Essentials of Probability and Statistical Inference II: Statistical Inference. 4 Credits.

Introduces students to the theory of statistical inference. Includes the frequentist, Bayesian and likelihood approaches to statistical inference including estimation, testing hypotheses and interval estimation. Emphasizes rigorous analysis (including proofs), as well as interpretation of results and simulation for illustration.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.648. Essentials of Probability and Statistical Inference III: Theory of Modern Statistical Methods. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.649. Essentials of Probability and Statistical Inference IV. 4 Credits.

Builds on the concepts discussed in 140.646, 140.647, 140.648 to provide the theory for modern statistical methods such as linear models, generalized linear models, random effects models, and marginal regression models. Also discusses the theory of causal inference. De-emphasizes proofs and replaces them with extended discussion of interpretation of results and simulation for illustration.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.651. Methods in Biostatistics I. 4 Credits.

Presents fundamental concepts in applied probability, exploratory data analysis, and statistical inference, focusing on probability and analysis of one and two samples. Includes topics discrete and continuous probability models; expectation and variance; central limit theorem; inference, including hypothesis testing and confidence interval for means, proportions, and counts; maximum likelihood estimation; sample size determinations; elementary non-parametric methods; graphical displays; and data transformations. Introduces R and concepts are presented both from a theoretical, practical and computational perspective.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.652. Methods in Biostatistics II. 4 Credits.

Presents fundamental concepts in applied probability, exploratory data analysis, and statistical inference, focusing on probability and analysis of one and two samples. Includes discrete and continuous probability models; expectation and variance; central limit theorem; inference, including hypothesis testing and confidence for means, proportions, and counts; maximum likelihood estimation; sample size determinations; elementary non-parametric methods; graphical displays; and data transformations.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.653. Methods in Biostatistics III. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.654. Methods in Biostatistics IV. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.655. Analysis of Longitudinal Data. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.656. Multilevel Statistical Models in Public Health. 4 Credits.

Explores conceptual and formal approaches to the design, analysis, and interpretation of studies with a "multilevel" or "hierarchical" (clustered) data structure (e.g., individuals in families in communities). Develops skills to implement and interpret random effects, variance component models that reflect the multi-level structure for both predictor and outcome variables. Includes topics: building hierarchies; interpretation of population-average and level-specific summaries; estimation and inference based on variance components; shrinkage estimation; discussion of special topics including centering, use of contextual variables, ecological bias, sample size and missing data within multilevel models. Supports STATA and R software.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.658. Statistics for Psychosocial Research: Structural Models. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.664. Causal Inference in Medicine and Public Health I. 4 Credits.

Presents an overview of methods for estimating causal effects: how to answer the question of "What is the effect of A on B?" Includes discussion of randomized designs, but with more emphasis on alternative designs for when randomization is infeasible: matching methods, propensity scores, regression discontinuity, and instrumental variables. Methods are motivated by examples from the health sciences, particularly mental health and community or school-level interventions. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.665. Causal Inference in Medicine and Public Health II. 3 Credits.

Presents principles, methods, and applications in drawing cause-effect inferences with a focus on the health sciences. Building on the basis of 140.664, emphasizes statistical theory and design and addresses complications and extensions, aiming at cultivating students' research skills in this area. Includes: detailed role of design for causal inference; role of models and likelihood perspective for ignorable treatment assignment; estimation of noncollapsible causal effects; statistical theory of propensity scores; use of propensity scores for estimating effect modification and for comparing multiple treatments while addressing regression to the mean; theory and methods of evaluating longitudinal treatments, including the role of sequentially ignorable designs and propensity scores; likelihood theory for instrumental variables and principal stratification designs and methods to deal with treatment noncompliance, direct and indirect effects, and censoring by death.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.673. INTRODUCTION TO STATISTICAL THEORY I. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.676. Biostatistical Analysis of Epidemiologic Data I: Basic Tools. 2 Credits.

Begins with a brief review of statistical estimation and probability distributions. Also included is an introduction to bootstrap methods of statistical estimation. Then, confidence intervals are explored in detail. The analysis of two of the most common and important biostatistical/epidemiological tools, namely 2 by 2 tables and 2 by k tables, follows. The roll of a variety of issues such as confounding variables, interaction, bias and independence, key elements in many statistical applications, are an additional focus of these discussions. Weighted averages are discussed particularly in the context of combining tables and estimates.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.677. Biostatistical Analysis of Epidemiologic Data II: Logistic Regression Analysis. 2 Credits.

Presents applications of regression techniques, starting with a review of simple linear regression, as a foundation. Followed by application to non-linear data using more general regression techniques. Then, a complete and extensive description of log-linear regression analysis (also called Poisson regression) and how it works, particularly for the application to count data and tables. Also included is the concept of quasi-independence and the analysis of incomplete tables. Logistic regression techniques are similarly described in detail with emphasis on application to epidemiologic binary outcome data in several contexts. All regression techniques are illustrated with applied examples.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.678. Biostatistics Analysis of Epidemiologic Data III. 2 Credits.

Discusses elementary survival analysis biostatistical tools such as the nonparametric techniques, life tables, Kaplan/Meire survival probabilities and cox regression. Equally, parametric approaches based on exponential and Weibull probability distributions are similarly discussed. Presents six statistical tools often useful in specific situations but rarely found in introductory texts. Two examples are the capture/recapture methods for estimating population sizes, both human and animal populations, and random response survey techniques that guarantee complete confidentiality.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.686. Advanced Methods for Statistical Genetics and Genomics. 3 Credits.

Covers statistical methods and theory underlying advanced analysis of genetic and genomic data to address mechanistic hypotheses and to build models for prediction. Topics include methods for complex association testing, inference on genetic architecture using mixed model techniques, methods for understanding causal mechanisms using Mendelian randomization, and integrative genomic analysis and strategies for clinical translation using risk prediction models. Requires making presentations and critiquing published studies that have used advance statistical methods to make new scientific observations.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.688. Statistics For Genomics. 3 Credits.

Covers the basics of R software and the key capabilities of the Bioconductor project (a widely used open source and open development software project for the analysis and comprehension of data arising from high-throughput experimentation in genomics and molecular biology and rooted in the open source statistical computing environment R), including importation and preprocessing of high-throughput data from microarrays and other platforms. Also introduces statistical concepts and tools necessary to interpret and critically evaluate the bioinformatics and computational biology literature. Includes an overview of preprocessing and normalization, statistical inference, multiple comparison corrections, Bayesian Inference in the context of multiple comparisons, clustering, and classification/machine learning.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.689. Adaptive Enrichment Designs for Confirmatory Randomized Trials: Methods and Software. 1 Credit.

Provides an overview of the strengths and limitations of randomized trial designs that adaptively change enrollment criteria during a trial (adaptive enrichment designs) and have the potential to provide improved information about which subpopulations benefit from new treatments. Explains recent advances in statistical methods for these designs, and presents adaptive design software planning tools. Discusses FDA guidance documents on adaptive designs. Examines methods for improving precision of estimators of the average treatment effect, by leveraging information in baseline variables; these methods can be used in adaptive designs as well as standard (non-adaptive) trial designs. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.698. Spatial Analysis III: Spatial Statistics. 4 Credits.

Introduces statistical techniques used to model, analyze, and interpret public health related spatial data. Analysis of spatially dependent data is cast into a general framework based on regression methodology. Topics covered include the geostatistical techniques of kriging and variogram analysis and point process methods for spatial case control and area-level analysis. Although the focus is on statistical modeling, students will also cover topics related to clustering and cluster detection of disease events. Although helpful, knowledge of specific GIS software is not required. Instruction in the public domain statistical package R/RStudio, (to be used for analysis), is provided.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.699. Spatial Analysis IV: Spatial Design and Application. 3 Credits.

Expands students' abilities to design, conduct and report the results of a complete public health related spatial analysis. Focuses on further developing and integrating components of the spatial science paradigm, Spatial Data, GIS and Spatial Statistics. Introduces relevant topics in GIS, spatial data technologies and spatial statistics not previously covered in Spatial Analysis I-III.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.711. Advanced Data Science I. 3 Credits.

In this course, we will focus on hands-on data analyses with a main objective of solving real-world problems. We will teach the necessary skills to gather, manage and analyze data using the R programming language. We will cover an introduction to data wrangling, exploratory data analysis, statistical inference and modeling, machine learning, and high-dimensional data analysis. We will also learn the necessary skills to develop data products including reproducible reports that can be used to effectively communicate results from data analyses. Students will train to become data scientists capable of both applied data analysis and critical evaluation of the next generation next generation of statistical methods.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.712. Advanced Data Science II. 3 Credits.

Builds on Advanced Data Science I by introducing the idea of data products and encouraging students to build products based on their data analyses.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.721. Probability Theory I. 3 Credits.

Presents the first part of the classical results of probability theory: measure spaces, LP spaces, probability measures, distributions, random variables, integration, and convergence theorems.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.722. Probability Theory II. 3 Credits.

Presents the first part of the classical results of probability theory: independence, types of convergence, laws of large numbers, Borel-Cantelli lemmas, Kolmogorov's zero-one law, random series and rates of convergence. Also discusses characteristic functions and weak convergence.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.723. Probability Theory III. 3 Credits.

Presents the second part of the classical results of probability theory: central limit theorems, Poisson convergence, coupling, Stein-Chen method, densities, derivatives and conditional expectations. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.724. Probability Theory IV. 3 Credits.

Covers basic stochastic processes including martingales and Markov chains, followed by consideration of Markov Chain Monte Carlo (MCMC) methods. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.731. Statistical Theory I. 4 Credits.

Introduces probability and inference, including random variables; probability distributions; transformations and sums of random variables; expectations, variances, and moments; properties of random samples; and hypothesis testing. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.732. Statistical Theory II. 4 Credits.

Introduces modern statistical theory; sets principles of inference based on decision theory and likelihood (evidence) theory; derives the likelihood function based on design and model assumptions; derives the complete class theorem between Bayes and admissible estimators; derives minimal sufficient statistics as a necessary and sufficient reduction of data for accurate inference in parametric models; derives the minimal sufficient statistics in exponential families; introduces maximum likelihood and unbiased estimators; defines information and derives the Cramer-Rao variance bounds in parametric models; introduces empirical Bayes (shrinkage) estimators and compares to maximum likelihood in small-sample problems. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.733. Statistical Theory III. 4 Credits.

Derives the large sample distribution of the maximum likelihood estimator under standard regularity conditions; develops the delta method and the large sample distribution of functions of consistent estimators, including moment estimators; introduces the theory of estimation in semiparametric regression models based on increasing approximation of parametric models; develops likelihood intervals and confidence intervals with exact or approximate properties; develops hypothesis tests through decision theory. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.734. Statistical Theory IV. 4 Credits.

Focuses on the asymptotic behavior of estimators, tests, and confidence interval procedures. Specific topics include: M-estimators; consistency and asymptotic normality of estimators; influence functions; large-sample tests and confidence regions; nonparametric bootstrap. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.741. Advanced Survival Analysis. 3 Credits.

Introduces statistical models and methods useful for analyzing univariate and multivariate failure time data. Extends Survival Analysis I to topics on length-bias and prevalent samplings, martingale theory, multivariate survival data, time-dependent ROC analysis, and recurrent event processes. Emphasizes nonparametric and semiparametric approaches for modeling, estimation and inferential results. Clinical and epidemiological examples included in class presentation illustrate statistical procedures. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.742. Risk Prediction and Precision Medicine. 3 Credits.

Covers various topics for evaluating the performance of biomarkers to predict risk of clinical or disease outcome, specifically including: a. relative, absolute and competing risks for binary and time-to-disease outcomes; b. ROC/AUC biomarker inference with binary outcome; c. ROC/AUC biomarker inference with time-to-event outcome, with censoring and truncation; d. statistical methods and inference for case-control study designs; e. a few topics on precision medicine. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.751. Advanced Methods in Biostatistics I. 3 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.752. Advanced Methods in Biostatistics II. 4 Credits.

Surveys basic statistical inference, estimates, tests and confidence intervals, and exploratory data analysis. Reviews probability distributions and likelihoods, independence and exchangeability, and modes of inference and inferential goals including minimizing MSE. Reviews linear algebra, develops the least squares approach to linear models through projections, and discusses connections with maximum likelihood. Covers linear, least squares regression, transforms, diagnostics, residual analysis, leverage and influence, model selection for estimation and predictive goals, departures from assumptions, efficiency and robustness, large sample theory, linear estimability, the Gauss Markov theorem, distribution theory under normality assumptions, and testing a linear hypothesis. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.753. Advanced Methods in Biostatistics III. 4 Credits.

Introduces generalized linear model (GLM). Foundational topics include: contingency tables, logistic regression for binary and binomial data, models for polytomous data, Poisson log-linear model for count data, and GLM for exponential family. Introduces methods for model fitting, diagnosis, interpretation and inference and expands on those topics with techniques for handling overdispersion, quasi-likelihood and conditional likelihood. Introduces the role of quantitative methods and sciences in public health, including how to use them to describe and assess population health, and the critical importance of evidence in advancing public health knowledge. Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.754. Advanced Methods in Biostatistics IV. 4 Credits.

Extends topics in 140.753 to encompass generalized linear mixed effects models. Introduces expectation-maximization and Markov Chain Monte Carlo. Introduces functional data analysis. Foundational topics include: linear mixed model, generalized linear mixed model, EM, MCMC, models for longitudinal data, and functional data analysis. Emphasizes both rigorous methodological development and practical data analytic strategies. Discusses the role of quantitative methods and sciences in public health, including how to use them to describe and assess population health, and the critical importance of evidence in advancing public health knowledge.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.762. Bayesian Methods I. 3 Credits.

Illustrates current approaches to Bayesian modeling and computation in statistics. Describes simple familiar models, such as those based on normal and binomial distributions, to illustrate concepts such as conjugate and noninformative prior distributions. Discusses aspects of modern Bayesian computational methods, including Markov Chain Monte Carlo methods (Gibbs' sampler) and their implementation and monitoring. Bayesian Methods I is the first term of a two term sequence. The second term offering, Bayesian Methods II (140.763), develops models of increasing complexity, including linear regression, generalized linear mixed effects, and hierarchical models.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.763. Bayesian Methods II. 3 Credits.

Builds upon the foundation laid in Bayesian Methods I (140.762). Discusses further current approaches to Bayesian modeling and computation in statistics. Describes and develops models of increasing complexity, including linear regression, generalized linear mixed effects, and hierarchical models. Acquaints students to advanced tools for fitting Bayesian models, including non-conjugate prior models. Includes examples of real statistical analyses.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.771. Advanced Statistical Theory I. 4 Credits.

Examines statistics as a discipline along the path towards making decisions. First examines the justification of statistics from axioms on informed preferences and its close connection to Bayesian theory, and then examines the role of standardizing intermediate steps, through various additional restrictions on estimation, and studies the properties of the resulting methods.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.772. Advanced Statistical Theory. 4 Credits.

Examines statistics as a discipline along the path towards making decisions. First examines the justification of statistics from axioms on informed preferences and its close connection to Bayesian theory, and then examines the role of standardizing intermediate steps, through various additional restrictions on estimation, and studies the properties of the resulting methods.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.773. Foundations of Statistical Inference. 4 Credits.

Investigates the foundations of statistics as applied to assessing the evidence provided by an observed set of data. Topics include: law of likelihood, the likelihood principle, evidence and the likelihood paradigm for statistical inference; failure of the Neyman-Pearson and Fisherian theories to evaluate evidence; marginal, conditional, profile and other likelihoods; and applications to common problems of inference.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.774. Foundations of Statistics II. 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.776. Statistical Computing. 3 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.778. Advanced Statistical Computing. 3 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.800. MPH Capstone Biostatistics. 2 Credits.

The MPH Capstone is an opportunity for students to work on public health practice projects that are of particular interest to them. The goal is for students to apply the skills and competencies they have acquired to a public health problem that simulates a professional practice experience.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.820. Thesis Research Biostatistics. 1 - 22 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.830. Postdoctoral Research Biostatistics. 1 - 22 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.840. Special Studies and Research Biostatistics. 1 - 22 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.850. Advanced Special Topics in Biostatistics. 1 - 22 Credits.

Exposes Biostatistics PhD students to advanced special topics that are not covered in the core courses. Comprises two- and four-week modules, with revolving instructors and topics. Possible topics include: theory underlying analysis for correlated data; latent variable modeling; advanced survival analysis; image analysis; time series; and likelihood inference.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.860. Current Topics in Biostatistics Research. 1 Credit.

Features presentations by Biostatistics faculty, postdocs and senior students on their research, with a focus on the public health and scientific questions driving the work, why the research makes a difference for the subject area and how to translate the research into practice. Offers an opportunity for discussion and clarification of key Biostatistical concepts being taught in the core courses and how they apply to problems in public health and science. Provides an opportunity for students and faculty to come together and discuss novel research questions and the role that Biostatisticians have in helping to support, enrich and promote solutions to these novel research questions.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.895. MPH Practicum: Biostatistics. 1 - 4 Credits.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.921. Biostats Lab for 140.621.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.922. Lab for Biostats 140.622.

Corequisite(s): Lab for PH.140.622

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.923. Lab for Biostats PH.140.623.

Corequisite(s): Must also enroll for PH.140.623

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.924. Lab for Biostatistics 140.624.

Corequisite(s): Must also enrol for PH.140.624

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.936. Lab - Scalable Computational Bioinformatics.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.941. Biostats Lab for 140.641.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.955. Lab for Biostat 140.655.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.958. Biostats Lab for 140.658.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).

PH.140.998. Lab for PH.140.698.

Course location and modality is found on the JHSPH website (<https://www.jhsph.edu/courses/>).