DEPARTMENT OF BIOSTATISTICS (GRAD)

The Department of Biostatistics is recognized as a worldwide leader in research and practice. Members of the faculty are interested both in the development of statistical methodology and application of statistics in applied research. The research strengths include: development of new statistical methods to address pressing issues in medicine and public health sciences; design of innovative clinical trials that allow faster evaluation of new therapeutic agents; collaborative work focused upon important public health concerns, including infectious diseases, cancer, cardiovascular disease, obesity and drinking water safety; and utilization of strong quantitative skills to improve the health of human beings around the globe.

The mission of the Department of Biostatistics is to forge dramatic advances in health science research that benefit human health in North Carolina, the U.S., and globally through the development of profound and paradigm-shifting innovations in biostatistical methodology and the thoughtful implementation of biostatistical practice to solve public health problems.


Master of Public Health (M.P.H.)

The redesigned UNC Gillings School of Global Public Health’s master of public health (M.P.H.) program is for people who are passionate about solving urgent local and global public health problems. With a legacy of outstanding education, cutting edge research and globally recognized leadership, the UNC Gillings School is creating the next generation of public health leaders through our integrated training program and 21st century curriculum. The Department of Biostatistics hosts the public health data science concentration.

Master of Science (M.S.)

The master of science (M.S.) degree in the Department of Biostatistics provides students with research-oriented training in the theory and methodology of biostatistics and its application to solving problems in the health sciences.

Doctor of Philosophy (Ph.D.)

The doctor of philosophy (Ph.D.) degree in the Department of Biostatistics provides advanced, research-oriented training in theory and methodology of biostatistics to prepare individuals for careers in academia, government, and industry.

Public Health, Master’s Program (M.P.H.) — Public Health Data Science Concentration

The Public Health Data Science concentration (https://sph.unc.edu/resource-pages/master-of-public-health-2/public-health-data-science-concentration/), one of the first applied data science programs situated within a school of public health, gives students the skills and knowledge to employ cutting-edge data science tools and respond to pressing public health issues with effective solutions. Data science draws upon multiple disciplines, combining the statistical skills to manipulate data and make inferences, the mathematical skills to model phenomena and make predictions, and the computer science skills to manage and analyze large data sets. Steeped in the public health context, our program offers a unique focus on leveraging the foundational statistical, mathematical, and computer science elements of data science to generate useful information from data sources relevant to public health.

Course Requirements

Requirements for the M.P.H. degree in the Public Health Data Science concentration

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tr>
<td>SPHG 711</td>
<td>Data Analysis for Public Health</td>
<td>2</td>
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<td>SPHG 712</td>
<td>Methods and Measures for Public Health Practice</td>
<td>2</td>
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<tr>
<td>SPHG 713</td>
<td>Systems Approaches to Understanding Public Health Issues</td>
<td>2</td>
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<td>SPHG 701</td>
<td>Leading from the Inside-Out</td>
<td>2</td>
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<td>SPHG 721</td>
<td>Public Health Solutions: Systems, Policy and Advocacy</td>
<td>2</td>
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<tr>
<td>SPHG 722</td>
<td>Developing, Implementing, and Evaluating Public Health Solutions (MPH Comprehensive Exam administered in class)</td>
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M.P.H. Practicum

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<tr>
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<tr>
<td>SPHG 703</td>
<td>MPH Pre-Practicum Assignments</td>
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<td>SPHG 707</td>
<td>MPH Post-Practicum Assignments</td>
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M.P.H. Concentration

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<tr>
<td>BIOS 512</td>
<td>Data Science Basics</td>
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<td>BIOS 650</td>
<td>Basic Elements of Probability and Statistical Inference</td>
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<td>BIOS 635</td>
<td>Introduction to Machine Learning</td>
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<tr>
<td>BIOS 645</td>
<td>Principles of Experimental Analysis</td>
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<tr>
<td>EPID 710</td>
<td>Fundamentals of Epidemiology</td>
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M.P.H. Electives

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<tr>
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<td>Elective (Graduate-level courses, 400+ level at Gillings, 500+ level at UNO)</td>
<td>3</td>
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<tr>
<td></td>
<td>Elective (Graduate-level courses, 400+ level at Gillings, 500+ level at UNO)</td>
<td>3</td>
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<tr>
<td></td>
<td>Elective (Graduate-level courses, 400+ level at Gillings, 500+ level at UNO)</td>
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M.P.H. Culminating Experience

<table>
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<th>Code</th>
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<tbody>
<tr>
<td>BIOS 992</td>
<td>Master’s (Non-Thesis)</td>
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</table>

Minimum Hours 42

Admissions

Please visit Applying to the Gillings School (https://sph.unc.edu/students/how-to-apply/) first for details and information. Application to the residential M.P.H. is a 2-step process. Please apply separately to (1) SOPHAS and (2) UNC—Chapel Hill (via the Graduate School application). Visit the Graduate School website (https://gradschool.sites.unc.edu/master-of-public-health/) for more details. If you are interested in the online M.P.H., please visit the MPH@UNC (https://onlinemph.unc.edu/) website and fill out an inquiry form.
Milestones

- Master’s Committee
- Master’s Written Examination/Approved Substitute (Comprehensive Exam)
- Thesis Substitute (Culminating Experience)
- Residence Credit
- Exit Survey
- Master’s Professional Work Experience (Practicum)

Master of Science in Biostatistics (M.S.)

The Master of Science (MS) program is designed to provide research-oriented training in the theory and methodology of biostatistics and its applications to the solution of problems in the health sciences.

Course Requirements

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>SPHG 600</td>
<td>Introduction to Public Health 1</td>
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<tr>
<td>EPID 600</td>
<td>Principles of Epidemiology for Public Health</td>
<td>3</td>
</tr>
<tr>
<td>or EPID 710</td>
<td>Fundamentals of Epidemiology</td>
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<tr>
<td>BIOS 511</td>
<td>Introduction to Statistical Computing and Data Management</td>
<td>4</td>
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<tr>
<td>BIOS 660</td>
<td>Probability and Statistical Inference I</td>
<td>3</td>
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<tr>
<td>BIOS 661</td>
<td>Probability and Statistical Inference II</td>
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<tr>
<td>BIOS 662</td>
<td>Intermediate Statistical Methods</td>
<td>4</td>
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<td>BIOS 663</td>
<td>Intermediate Linear Models</td>
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<tr>
<td>BIOS 667</td>
<td>Applied Longitudinal Data Analysis</td>
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<tr>
<td>BIOS 680</td>
<td>Introductory Survivorship Analysis</td>
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<tr>
<td>BIOS 691</td>
<td>Field Observations in Biostatistics</td>
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<tr>
<td>BIOS 841</td>
<td>Principles of Statistical Collaboration and Leadership</td>
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<tr>
<td>BIOS 843</td>
<td>Seminar in Biostatistics (two semesters, 2 credit hours) 2</td>
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Electives 3,4

Six hours of course work that can include BIOS 635, 664, 665, and 668 or any course higher than 668 but not including 680 in Biostatistics.

Thesis/Substitute or Dissertation Course

BIOS 992 Master’s (Non-Thesis) 3

Minimum Hours 45

1. Students with a prior public health degree are not required to take SPHG 600; exemptions are available for those with non-public health degrees from accredited SPHs. Students should discuss with their Academic Coordinator.

2. BIOS 843 Seminar must be taken two semesters for two credit hours after comprehensive exams.

3. Six hours of course work that can include BIOS 635, 664, 665, and 668 or any course higher than 668 but not including 680 in Biostatistics, or equivalent in the Department of Statistics and Operations Research (STOR) at UNC, or in the Department of Statistics at North Carolina State University (NCSU); these hours are considered individually and must be approved by the DGS.

4. Students interested in substituting a graduate level course (600 level or higher) outside of the Gillings School of Global Public Health should submit a request to the Academic Coordinator for review by the DGS for consideration.

Doctor of Philosophy in Biostatistics (Ph.D.)

The doctor of philosophy (Ph.D.) degree in the Department of Biostatistics provides advanced, research-oriented training in theory and methodology of biostatistics to prepare individuals for careers in academia, government, and industry.

Course Requirements

<table>
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<tr>
<th>Code</th>
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<tbody>
<tr>
<td>SPHG 600</td>
<td>Introduction to Public Health 1</td>
<td>3</td>
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<tr>
<td>EPID 600</td>
<td>Principles of Epidemiology for Public Health</td>
<td>3</td>
</tr>
<tr>
<td>or EPID 710</td>
<td>Fundamentals of Epidemiology</td>
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</tr>
<tr>
<td>BIOS 511</td>
<td>Introduction to Data Science</td>
<td>4</td>
</tr>
<tr>
<td>BIOS 660</td>
<td>Probability and Statistical Inference I</td>
<td>3</td>
</tr>
<tr>
<td>BIOS 661</td>
<td>Probability and Statistical Inference II</td>
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<tr>
<td>BIOS 662</td>
<td>Intermediate Statistical Methods</td>
<td>4</td>
</tr>
<tr>
<td>BIOS 663</td>
<td>Intermediate Linear Models</td>
<td>4</td>
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<tr>
<td>BIOS 667</td>
<td>Topics in Real Analysis, Introduction to Measure Theory</td>
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<tr>
<td>BIOS 673</td>
<td>Intermediate Statistical Inference</td>
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<td>BIOS 735</td>
<td>Statistical Computing - Basic Principles and Applications</td>
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<tr>
<td>BIOS 760</td>
<td>Advanced Probability and Statistical Inference I</td>
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<tr>
<td>BIOS 761</td>
<td>Advanced Probability and Statistical Inference II</td>
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Milestones

- Master’s Committee
- Master’s Written Exam / Approved Substitute
- Thesis Substitute
- Residence Credit
- Exit Survey
- Master’s Written Exam 2

1. Students with a prior public health degree are not required to take SPHG 600; exemptions are available for those with non-public health degrees from accredited SPHs. Students should discuss with their Academic Coordinator.

2. BIOS 843 Seminar must be taken two semesters for two credit hours after comprehensive exams.

3. Six hours of course work that can include BIOS 635, 664, 665, and 668 or any course higher than 668 but not including 680 in Biostatistics, or equivalent in the Department of Statistics and Operations Research (STOR) at UNC, or in the Department of Statistics at North Carolina State University (NCSU); these hours are considered individually and must be approved by the DGS.

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- Doctoral Committee
- Doctoral Oral Comprehensive Exam
- Doctoral Written Exam
- Prospectus Oral Exam
- Advanced to Candidacy
- Dissertation Defense
- Doctoral Dissertation Approved/Format Accepted
- Residence Credit
- Exit Survey

Following the faculty member's name is a section number that students should use when registering for independent studies, reading, research, and thesis and dissertation courses with that particular professor.

### Professors

- **Kevin Anstrom (70)**, Clinical Trials, Statistical Consulting, Causal Inference, Data Safety Monitoring, Pragmatic Clinical Trials, and Coordinating Center Operations
- **Jianwen Cai (93)**, Survival Analysis and Regression Models, Clinical Trials, Analysis of Correlated Responses
- **David J. Couper (77)**, Epidemiological Methods, Longitudinal Data, Data Quality
- **Michael Hudgens (42)**, Nonparametric Estimation, Group Testing, Causal Inference, Infectious Diseases
- **Joseph G. Ibrahim (11)**, Bayesian Inference, Missing Data Problems, Bayesian Survival Analysis, Generalized Linear Models, Genomics
- **Anastasia Ivanova (83)**, Clinical Trials Design, Sequential Design of Binary Response Experiments, Statistical Methodology in Biostatistics
- **Gary G. Koch (14)**, Categorical Data Analysis, Nonparametric Methods
- **Michael R. Kosorok (88)**, Biostatistics, Bioinformatics, Empirical Processes, Statistical Learning, Data Mining, Semiparametric Inference, Monte Carlo Methods, Survival Analysis, Clinical Trials, Personalized Medicine, Cancer, Cystic Fibrosis
- **Yun Li (59)**, (Joint with the Department of Genetics), Statistical Genetics
- **Danyu Lin (31)**, Survival Analysis, Semiparametric Statistical Methods, Clinical Trials
- **Feng-Chang Lin (71)**, Survival Analysis, Generalized Linear Models, Longitudinal Analysis, Heart Disease and Stroke, Infectious Disease, Neuroscience
- **Yufeng Liu (73)**, (Joint with the Department of Statistics and Operations Research), Statistical Machine Learning and Data Mining, High-Dimensional Data Analysis, Nonparametric Statistics and Functional Estimation, Bioinformatics, Design and Analysis of Experiments
- **James Stephen Marron (82)**, (Joint with the Department of Statistics and Operations Research), High Dimension Low Sample Size (HDLSS), Data and/or Data, Exotic Data Types such as Manifold and Tree-Structural Data
- **Jane Monaco (43)**, Survival Analysis, Correlated Failure Time Data
- **Andrew Nobel**, (Joint with the Department of Statistics and Operations Research), Data Mining, Statistical Data of Genomic Data, Machine Learning
- **John S. Preisser Jr. (89)**, Categorical Data, Longitudinal Data Analysis
- **Bahjat Qaqish (94)**, Generalized Linear Models, Survival Analysis, Statistical Computing
- **Todd A. Schwartz (13)**, Categorical Data, Clinical Trials

### Code Title Hours

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<tr>
<td>BIOS 740</td>
<td>Specialized Methods in Health Statistics</td>
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<tr>
<td>BIOS 752</td>
<td>Design and Analysis of Clinical Trials</td>
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<tr>
<td>BIOS 764</td>
<td>Advanced Survey Sampling Methods</td>
<td>3</td>
</tr>
<tr>
<td>BIOS 765</td>
<td>Models and Methodology in Categorical Data</td>
<td>3</td>
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<tr>
<td>BIOS 772</td>
<td>Statistical Analysis of MRI Images</td>
<td>3</td>
</tr>
<tr>
<td>BIOS 773</td>
<td>Statistical Analysis with Missing Data</td>
<td>3</td>
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<tr>
<td>BIOS 774</td>
<td>Advanced Machine Learning</td>
<td>3</td>
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<tr>
<td>BIOS 782</td>
<td>Statistical Methods in Genetic Association Studies</td>
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<tr>
<td>BIOS 784</td>
<td>Introduction to Computational Biology</td>
<td>3</td>
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<tr>
<td>BIOS 785</td>
<td>Statistical Methods for Gene Expression Analysis</td>
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<td>BIOS 775</td>
<td>Statistical Methods in Diagnostic Medicine</td>
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<tr>
<td>BIOS 776</td>
<td>Causal Inference in Biomedical Research</td>
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<tr>
<td>BIOS 777</td>
<td>Precision Medicine and Machine Learning</td>
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<td>BIOS 779</td>
<td>Bayesian Statistics</td>
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<tr>
<td>BIOS 781</td>
<td>Statistical Methods in Human Genetics</td>
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<td>STOR 701</td>
<td>Statistics and Operations Research Colloquium</td>
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<td>STOR 712</td>
<td>Optimization for Machine Learning and Data Science</td>
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<td>STOR 713</td>
<td>Mathematical Programming II</td>
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<td>STOR 722</td>
<td>Integer Programming</td>
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<td>STOR 734</td>
<td>Stochastic Processes</td>
<td>3</td>
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<td>STOR 743</td>
<td>Reinforcement Learning and Markov Decision Processes</td>
<td>3</td>
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<td>STOR 754</td>
<td>Time Series and Multivariate Analysis</td>
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<td>STOR 757</td>
<td>Bayesian Statistics and Generalized Linear Models</td>
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<tr>
<td>STOR 767</td>
<td>Advanced Statistical Machine Learning</td>
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- **Bahjat Qaqish (94)**, Generalized Linear Models, Survival Analysis, Statistical Computing
- **Todd A. Schwartz (13)**, Categorical Data, Clinical Trials
Daniela T. Sotres-Alvarez (74), Linear Mixed Models, Latent Variable Models, Dietary and Physical Activity Patterns
Xianming Tan (50), Finite Mixture Models, Design of Clinical Studies, Variable Selection for Zero-Inflated Models, Non-Parametric Regression
Kinh N. Truong (90), Time Series Analysis, Nonparametric Regression, Bootstrap Methods, Hazard Regression, Splines
Haibo Zhou (40), Missing/Auxiliary Data, Survival Analysis, Human Fertility
Hongtu Zhu (48), Neuroimaging Statistics, Structural Equation Models, Statistical Computing, Diagnostic Methods
Fei Zou (4), Statistical Genetics

Associate Professors
Robert Agans (78), Population-Based Research Methods, Multimode Data Collection Procedures, Questionnaire Development, Standardization and Validation, Hard-to-Reach Populations and Minorities
Jamie B. Crandell (64), (Joint with the School of Nursing), Bayesian Methods, Longitudinal Analysis and Measurement Error Modeling
Tanya P. Garcia (67), Survival Analysis, Semiparametric Theory, Longitudinal Data Analysis
Annie Green Howard (75), Cardiovascular Disease, Global Health
Yuchao Jiang (91), Statistical Modeling, Method Development and Data Analysis in Genetics and Genomics
Quefeng Li (81), High Dimensional Data Analysis, Integrative Analysis of Omics Data, Robust Statistics, Factor Models
Michael I. Love (39), (Joint with the Department of Genetics), Statistical Modeling of Genetics Data, High-Throughput Sequencing, RNA Sequencing (RNA-seq), Empirical Bayes Methods
Naim Rashid (79), Cancer, Genomics, High Throughput Sequencing, High Dimensional Data Analysis, Variable Selection
Di Wu (51), (Joint with the School of Dentistry), Statistical Bioinformatics and Biostatistics for Preprocess and Integration of High-Dimensional Biomedical Data
Baiming Zou (97), Robust Modeling of Data with Complex Structures, Machine Learning Methods for Large Scale Electronic Health Record Data Analysis

Assistant Professors
Ethan Alt, Bayesian Methods, Clinical Trial Design
Didong Li (80), Geometric Data Analysis, Information Geometry, Nonparametric Bayes, Spatial Statistics
Xihao Li, Statistical Genetics and Genomics, Integrative Analysis of WGS/WES and Multi-Omics Data, Functional Genomics and Annotations, Data Integration and Meta-Analysis, Multivariate Analysis, Machine Learning
Yusha Liu, Cancer, Single-Cell Modeling, Multi-Omics Data Integration, Bayesian Inference, Functional Data Analysis, and Quantile Regression
Kara McCormack (85), Statistical Pedagogy, Classroom Accessibility and Inclusivity
Bonnie Shock-Sa (98), Causal Inference, Survey Sampling, Infectious Diseases, Epidemiology

Instructors
Jane Eslinger (62)
Kinsey Helton
Marcus Herman-Giddens
Jeff Laux
Vincent Toups (17)

Adjunct Professors
Shanshan Zhao
Xiaojing Zheng

Adjunct Associate Professors
Charles Pepe-Ranney
Matthew Psioda
Zhengwu Zhang

Professors Emeriti
Shrikant I. Bangdiwala
Lloyd E. Chambless
Clarence E. Davis
James E. Grizzle
Ronald W. Helms
William D. Kalsbeek
Lawrence L. Kupper
Lisa M. LaVange
Keith E. Muller
Dana E. Quade
Michael J. Symons

BIOS
Advanced Undergraduate and Graduate-level Courses
BIOS 500H. Introduction to Biostatistics. 3 Credits. Access to SAS, Excel required. Permission of instructor for nonmajors. Introductory course in probability, data analysis, and statistical inference designed for B.S.P.H. biostatistics students. Topics include sampling, descriptive statistics, probability, confidence intervals, tests of hypotheses, chi-square distribution, 2-way tables, power, sample size, ANOVA, non-parametric tests, correlation, regression, survival analysis.

Rules & Requirements
Requisites: Prerequisite, MATH 231 and 232; corequisite, BIOS 511.
Grading Status: Letter grade.

BIOS 511. Introduction to Statistical Computing and Data Management. 4 Credits.
Required preparation, previous or concurrent course in applied statistics. Permission of instructor for nonmajors. Introduction to use of computers to process and analyze data, concepts and techniques of research data management, and use of statistical programming packages and interpretation. Focus is on use of SAS for data management and reporting.

Rules & Requirements
Grading Status: Letter grade.
BIOS 512. Data Science Basics. 3 Credits.
Students will gain proficiency with R, data wrangling, data quality control and cleaning, data visualization, exploratory data analysis, with an overall emphasis on the principles of good data science, particularly reproducible research. The course will also develop familiarity with several software tools for data science best practices, such as Git, Docker, Jupyter, Make, and Nextflow.

Rules & Requirements
Grading Status: Letter grade.

BIOS 540. Problems in Biostatistics. 1-15 Credits.
Arrangements will be made with the faculty in each case. A course for students of public health who wish to make a study of some special problem in the statistics of the life sciences and public health. Honors version available.

Rules & Requirements
Repeat Rules: May be repeated for credit. 15 total credits. 4 total completions.
Grading Status: Letter grade.

BIOS 600. Principles of Statistical Inference. 3 Credits.
Required preparation, knowledge of basic descriptive statistics. Major topics include elementary probability theory, probability distributions, estimation, tests of hypotheses, chi-squared procedures, regression, and correlation.

Rules & Requirements
Grading Status: Letter grade.

BIOS 611. Introduction to Data Science. 4 Credits.
Topics will include gaining proficiency with R and Python, data wrangling, data quality control and cleaning, data visualization, exploratory data analysis, and introductory applied optimization, with an overall emphasis on the principles of good data science, particularly reproducible research. Some emphasis will be given to large data settings such as genomics or claims data. The course will also develop familiarity with software tools for data science best practices, such as Git, Docker, Jupyter, and Nextflow.

Rules & Requirements
Requisites: Prerequisites, MATH 232 and 416, and STOR 151.
Grading Status: Letter grade.

BIOS 635. Introduction to Machine Learning. 3 Credits.
This course will be an introductory course to machine learning. The goal is to equip students with knowledge of existing tools for data analysis and to prepare students for more advanced courses in machine learning. Students in the SPH Master of Public Health with a Public Health Data Science concentration receive priority for enrollment.

Rules & Requirements
Requisites: Prerequisite, BIOS 512 or 650; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 641. Quantitative Methods for Health Care Professionals I. 4 Credits.
Course is designed to meet the needs of health care professionals to appraise the design and analysis of medical and health care studies and who intend to pursue academic research careers. Covers basics of statistical inference, analysis of variance, multiple regression, categorical data analysis. Previously offered as PUBH 741. Permission of instructor.

Rules & Requirements
Grading Status: Letter grade.

BIOS 642. Quantitative Methods for Health Care Professionals II. 4 Credits.
Continuation of BIOS 641. Main emphasis is on logistic regression; other topics include exploratory data analysis and survival analysis. Previously offered as PUBH 742.

Rules & Requirements
Requisites: Prerequisite, BIOS 641.
Grading Status: Letter grade.

BIOS 645. Principles of Experimental Analysis. 3 Credits.
Required preparation, basic familiarity with statistical software (preferably SAS able to do multiple linear regression) and introductory biostatistics, such as BIOS 600. Continuation of BIOS 600. Analysis of experimental and observational data, including multiple regression and analysis of variance and covariance. Previously offered as BIOS 545. Permission of the instructor for nonmajors.

Rules & Requirements
Requisites: Prerequisites, BIOS 600 or SPHG 711.
Grading Status: Letter grade.

BIOS 650. Basic Elements of Probability and Statistical Inference I. 3 Credits.
Required preparation, two semesters of calculus (such as MATH 231, 232). Fundamentals of probability; discrete and continuous distributions; functions of random variables; descriptive statistics; fundamentals of statistical inference, including estimation and hypothesis testing.

Rules & Requirements
Grading Status: Letter grade.

BIOS 661. Probability and Statistical Inference II. 3 Credits.
Distribution of functions of random variables; Helmhert transformation theory; central limit theorem and other asymptotic theory; estimation theory; maximum likelihood methods; hypothesis testing; power; Neyman-Pearson Theorem, likelihood ratio, score, and Wald tests; noncentral distributions.

Rules & Requirements
Requisites: Prerequisite, BIOS 660; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
BIOS 662. Intermediate Statistical Methods. 4 Credits.
Principles of study design, descriptive statistics, sampling from finite and infinite populations, inferences about location and scale. Both distribution-free and parametric approaches are considered. Gaussian, binomial, and Poisson models, one-way and two-way contingency tables.

Rules & Requirements
Requisites: Pre- or corequisites, BIOS 511 and 650.
Grading Status: Letter grade.

BIOS 663. Intermediate Linear Models. 4 Credits.
Required preparation, BIOS 662. Matrix-based treatment of regression, one-way and two-way ANOVA, and ANCOVA, emphasizing the general linear model and hypothesis, as well as diagnostics and model building. Reviews matrix algebra. Includes statistical power for linear models and binary response regression methods.

Rules & Requirements
Grading Status: Letter grade.

BIOS 664. Sample Survey Methodology. 4 Credits.
Fundamental principles and methods of sampling populations, with emphasis on simple, random, stratified, and cluster sampling. Sample weights, nonsampling error, and analysis of data from complex designs are covered. Practical experience through participation in the design, execution, and analysis of a sampling project.

Rules & Requirements
Requisites: Prerequisite, BIOS 650; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
Same as: STOR 358.

BIOS 665. Analysis of Categorical Data. 3 Credits.
Introduction to the analysis of categorized data: rates, ratios, and proportions; relative risk and odds ratio; Cochran-Mantel-Haenszel procedure; survivorship and life table methods; linear models for categorical data. Applications in demography, epidemiology, and medicine.

Rules & Requirements
Requisites: Prerequisites, BIOS 645, 650, and 662; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 666. Design of Public Health Studies. 3 Credits.
Statistical concepts in basic public health study designs: cross-sectional, case-control, prospective, and experimental (including clinical trials). Validity, measurement of response, sample size determination, matching and random allocation methods.

Rules & Requirements
Requisites: Prerequisites, BIOS 645 and 650.
Grading Status: Letter grade.

BIOS 667. Applied Longitudinal Data Analysis. 3 Credits.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and BIOS 663; permissions from the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 668. Design of Public Health Studies. 3 Credits.
Statistical concepts in basic public health study designs: cross-sectional, case-control, prospective, and experimental (including clinical trials). Validity, measurement of response, sample size determination, matching and random allocation methods.

Rules & Requirements
Requisites: Prerequisites, BIOS 645 and 650.
Grading Status: Letter grade.

BIOS 669. Working with Data in a Public Health Research Setting. 3 Credits.
Provides a foundation and training for working with data from clinical trials or research studies. Topics: issues in study design, collecting quality data, using SAS and SQL to transform data, typical reports, data closure and export, and working with big data.

Rules & Requirements
Grading Status: Letter grade.

BIOS 670. Intermediate Statistical Inference. 1 Credits.
This course introduces intermediate concepts and theories in statistical inferences, including multivariate transformation, convergence of random vectors, sufficient and complete statistics, methods of estimation, and advanced problems such as information inequality, unbiased estimators, Bayes estimators, asymptotically efficient estimation, nonparametric estimation, and simultaneous confidence intervals.

Rules & Requirements
Requisites: Corequisite, BIOS 660.
Grading Status: Letter grade.

BIOS 671. Topics in Real Analysis, Introduction to Measure Theory. 1 Credits.
Selected topics in calculus, real analysis including Taylor’s series, Riemann, Stieltjes and Lebesgue integration, and complex variables. Introduction to measure theory.

Rules & Requirements
Requisites: BIOS 660.
Grading Status: Letter grade.

BIOS 680. Introductory Survivorship Analysis. 3 Credits.
Introduction to concepts and techniques used in the analysis of time to event data, including censoring, hazard rates, estimation of survival curves, regression techniques, applications to clinical trials.

Rules & Requirements
Requisites: Prerequisite, BIOS 661; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
BIOS 690. Special Topics in Biostatistics. 1-3 Credits.
Field/topical/research seminar. Instructors use this course to offer instruction in particular topics or approaches.

Rules & Requirements
Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 6 total completions.
Grading Status: Letter grade.

BIOS 691. Field Observations in Biostatistics. 1 Credits.
Field visits to, and evaluation of, major nonacademic biostatistical programs in the Research Triangle area. Field fee: $25.

Rules & Requirements
Grading Status: Letter grade.

BIOS 692. IDEAs in Action Gen Ed: RESEARCH.
Grading Status: Letter grade.

BIOS 693H. Honors Research in Biostatistics. 3 Credits.
Directed research. Written and oral reports required.

Rules & Requirements
Grading Status: Letter grade.

Graduate-level Courses

BIOS 700. Research Skills in Biostatistics. 1 Credits.
Permission of the department for students with passing grade of either doctoral qualifying examination in biostatistics. BIOS 700 will introduce doctoral students in biostatistics to research skills necessary for writing a dissertation and for a career in research.

Rules & Requirements
Requisites: Prerequisites, BIOS 760, 761 or 758, 762, 763, and 767.
Grading Status: Letter grade.

BIOS 735. Statistical Computing - Basic Principles and Applications. 4 Credits.
Required preparation, one undergraduate-level programming class. Teaches important concepts and skills for statistical software development using case studies. After this course, students will have an understanding of the process of statistical software development, knowledge of existing resources for software development, and the ability to produce reliable and efficient statistical software.

Rules & Requirements
Requisites: Prerequisites, BIOS 660, 661, 662, and 663.
Grading Status: Letter grade.

BIOS 740. Specialized Methods in Health Statistics. 1-21 Credits.
Permission of the instructor. Statistical theory applied to special problem areas of timely importance in the life sciences and public health. Lectures, seminars, and/or laboratory work, according to the nature of the special area under study.

Rules & Requirements
Grading Status: Letter grade.

BIOS 752. Design and Analysis of Clinical Trials. 3 Credits.
This course will introduce the methods used in clinical. Topics include dose-finding trials, allocation to treatments in randomized trials, sample size calculation, interim monitoring, and non-inferiority trials.

Rules & Requirements
Requisites: Prerequisites, BIOS 600 and 661.
Grading Status: Letter grade.

BIOS 756. Advanced Nonparametric Methods in Biometric Research. 3 Credits.
Theory and application of nonparametric methods for various problems in statistical analysis. Includes procedures based on randomization, ranks and U-statistics. A knowledge of elementary computer programming is assumed.

Rules & Requirements
Requisites: Prerequisite, BIOS 661.
Grading Status: Letter grade.

BIOS 760. Advanced Probability and Statistical Inference I. 4 Credits.
Measure space, sigma-field, measurable functions, integration, conditional probability, distribution functions, characteristic functions, convergence modes, SLLN, CLT, Cramer-Wold device, delta method, U-statistics, martingale central limit theorem, UMVUE, estimating function, MLE, Cramer-Rao lower bound, information bounds, LeCam's lemmas, consistency, efficiency, EM algorithm.

Rules & Requirements
Requisites: Prerequisite, BIOS 661; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 761. Advanced Probability and Statistical Inference II. 4 Credits.

Rules & Requirements
Requisites: Prerequisite, BIOS 760; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 762. Theory and Applications of Linear and Generalized Linear Models. 4 Credits.
Linear algebra, matrix decompositions, estimability, multivariate normal distributions, quadratic forms, Gauss-Markov theorem, hypothesis testing, experimental design, general likelihood theory and asymptotics, delta method, exponential families, generalized linear models for continuous and discrete data, categorical data, nuisance parameters, over-dispersion, multivariate linear model, generalized estimating equations, and regression diagnostics.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663, MATH 547, and 416 or 577; Co-requisite, BIOS 760.
Grading Status: Letter grade.
BIOS 764. Advanced Survey Sampling Methods. 3 Credits.
Continuation of BIOS 664 for advanced students: stratification, special designs, multistage sampling, cost studies, nonsampling errors, complex survey designs, employing auxiliary information, and other miscellaneous topics.

Rules & Requirements
Requisites: Prerequisite, BIOS 664.
Grading Status: Letter grade.

BIOS 765. Models and Methodology in Categorical Data. 3 Credits.
Theory and application of methods for categorical data including maximum likelihood, estimating equations and chi-square methods for large samples, and exact inference for small samples.

Rules & Requirements
Requisites: Prerequisites, BIOS 661, 663 and 665 or permission of instructor.
Grading Status: Letter grade.

BIOS 767. Longitudinal Data Analysis. 4 Credits.
Prereq: BIOS 662.
Present methods for the analysis of longitudinal data. Topics include linear mixed effects models, generalized linear models for correlated data (including generalized estimating equations), computational issues and methods for fitting models, and dropout or other missing data.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 762; Permission of the instructor for nonmajors.
Grading Status: Letter grade.

BIOS 771. Demographic Techniques II. 3 Credits.
Required preparation, integral calculus. Life table techniques; methods of analysis when data are deficient; population projection methods; interrelations among demographic variables; migration analysis; uses of population models.

Rules & Requirements
Requisites: Prerequisite, BIOS 670.
Grading Status: Letter grade.

BIOS 772. Statistical Analysis of MRI Images. 3 Credits.
The course will review major statistical methods for the analysis of MRI and its applications in various studies.

Rules & Requirements
Grading Status: Letter grade.

BIOS 773. Statistical Analysis with Missing Data. 3 Credits.
Fundamental concepts, including classifications of missing data, missing covariate and/or response data in linear models, generalized linear models, longitudinal data models, and survival models. Maximum likelihood methods, multiple imputation, fully Bayesian methods, and weighted estimating equations. Focus on biomedical sciences case studies. Software packages include WinBUGS, SAS, and R.

Rules & Requirements
Requisites: Prerequisites, BIOS 761 and 762.
Grading Status: Letter grade.

BIOS 774. Advanced Machine Learning. 3 Credits.
This advanced machine learning course, designed for PhD students in biostatistics and related fields, covers modern techniques for fitting models, and dropout or other missing data.

Rules & Requirements
Requisites: Prerequisite, BIOS 760; BIOS 762 and one of the following: BIOS 635, BIOS 735, STOR 565, STOR 767, CS 755; Instructor Consent.
Grading Status: Letter grade.

BIOS 775. Statistical Methods in Diagnostic Medicine. 3 Credits.
Prerequisites, BIOS 661 and 663; permission of the instructor for students lacking the prerequisite.

Rules & Requirements
Requisites: Prerequisites, BIOS 761 and 762.
Grading Status: Letter grade.

BIOS 776. Causal Inference in Biomedical Research. 3 Credits.
Prerequisite, BIOS 762; permission of the instructor for students lacking the prerequisite.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 777. Precision Medicine and Machine Learning. 3 Credits.
Prerequisite, BIOS 762; permission of the instructor for students lacking the prerequisite.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663 or equivalent.
Grading Status: Letter grade.

BIOS 779. Bayesian Statistics. 4 Credits.
Topics include Bayes' theorem, the likelihood principle, prior distributions, posterior distributions, predictive distributions, Bayesian modeling, informative prior elicitation, model comparisons, Bayesian diagnostic methods, variable subset selection, and model uncertainty. Markov chain Monte Carlo methods for computation are discussed in detail.

Rules & Requirements
Requisites: Prerequisite, BIOS 762; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
BIOS 780. Theory and Methods for Survival Analysis. 3 Credits.
Counting process-martingale theory, Kaplan-Meier estimator, weighted
log-rank statistics, Cox proportional hazards model, nonproportional
hazards models, multivariate failure time data.

Rules & Requirements
Requisites: Prerequisites, BIOS 760 and 761; permission of the instructor
for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 781. Statistical Methods in Human Genetics. 4 Credits.
An introduction to statistical procedures in human genetics, Hardy-
Weinberg equilibrium, linkage analysis (including use of genetic software
packages), linkage disequilibrium and allelic association.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; permission of the instructor
for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 782. Statistical Methods in Genetic Association Studies. 3
Credits.
This course provides a comprehensive survey of the statistical methods
for the designs and analysis of genetic association studies, including
genome-wide association studies and next-generation sequencing
studies. The students will learn the theoretical justifications for the
methods as well as the skills to apply them to real studies.

Rules & Requirements
Requisites: Prerequisite, BIOS 760.
Grading Status: Letter grade.

BIOS 784. Introduction to Computational Biology. 3 Credits.
Molecular biology, sequence alignment, sequence motifs identification by
Monte Carlo Bayesian approaches, dynamic programming, hidden Markov
models, computational algorithms, statistical software, high-throughput
sequencing data and its application in computational biology.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; Permission of the instructor
for students lacking the prerequisites.
Grading Status: Letter grade.
Same as: BCB 784.

BIOS 785. Statistical Methods for Gene Expression Analysis. 3
Credits.
Clustering algorithms, classification techniques, statistical techniques for
analyzing multivariate data, analysis of high dimensional data, parametric
and semiparametric models for DNA microarray data, measurement
error models, Bayesian methods, statistical software, sample size
determination in microarray studies, applications to cancer.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 or 673, and 663; Permission of the
instructor for students lacking the prerequisites.
Grading Status: Letter grade.
Same as: BCB 785.

BIOS 791. Empirical Processes and Semiparametric Inference. 3
Credits.
Theory and applications of empirical process methods to semiparametric
estimation and inference for statistical models with both finite and
infinite dimensional parameters. Topics include bootstrap, Z-estimators,
M-estimators, semiparametric efficiency.

Rules & Requirements
Requisites: Prerequisite, BIOS 761; permission of the instructor for
students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 841. Principles of Statistical Collaboration and Leadership. 3
Credits.
An introduction to the statistical collaborative process and leadership
skills. Emphasized topics include problem solving, study design, data
analysis, ethical conduct, teamwork, career paths, data management,
written and oral communication with scientists and collaborators.

Rules & Requirements
Grading Status: Letter grade.

BIOS 842. Practice in Statistical Consulting. 1-21 Credits.
Under supervision of a faculty member, the student interacts with
research workers in the health sciences, learning to abstract the
statistical aspects of substantive problems, to provide appropriate
technical assistance, and to communicate statistical results.

Rules & Requirements
Requisites: Prerequisites, BIOS 511, 645, 650, and 841; Permission of the
instructor for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 843. Seminar in Biostatistics. 1 Credits.
This seminar course is intended to give students exposure to cutting
edge research topics and hopefully help them in their choice of a thesis
topic. It also allows the student to meet and learn from major researchers
in the field.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

BIOS 844. Leadership in Biostatistics. 3 Credits.
Using lectures and group exercises, students are taught where and how
biostatisticians can offer leadership in both academic and nonacademic
public health settings.

Rules & Requirements
Requisites: Prerequisite, BIOS 841.
Grading Status: Letter grade.

BIOS 850. Training in Statistical Teaching in the Health Sciences. 1-21
Credits.
Required preparation, a minimum of one year of graduate work in
statistics. Principles of statistical pedagogy. Students assist with
teaching elementary statistics to students in the health sciences.
Students work under the supervision of the faculty, with whom they have
regular discussions of methods, content, and evaluation of performance.

Rules & Requirements
Grading Status: Letter grade.
BIOS 889. Research Seminar in Biostatistics. 0.5-21 Credits.
Permission of the instructor. Seminar on new research developments in selected biostatistical topics.

Rules & Requirements
Grading Status: Letter grade.

BIOS 990. Research in Biostatistics. 1-21 Credits.
Individual arrangements may be made by the advanced student to spend part or all of his or her time in supervised investigation of selected problems in statistics.

Rules & Requirements
Grading Status: Letter grade.

BIOS 992. Master's (Non-Thesis). 3 Credits.

Rules & Requirements
Repeat Rules: May be repeated for credit.

BIOS 994. Doctoral Research and Dissertation. 3 Credits.

Rules & Requirements
Repeat Rules: May be repeated for credit.

Contact Information
Department of Biostatistics
Visit Program Website (http://www.sph.unc.edu/bios/)

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Michael G. Hudgens

Associate Chair
Todd A. Schwartz