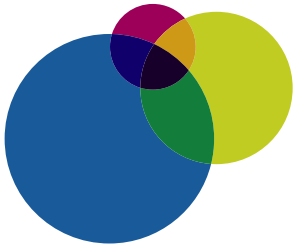


THE DEPARTMENT OF BIOSTATISTICS

STUDENT HANDBOOK

2016 - 2017

COLUMBIA UNIVERSITY | MAILMAN SCHOOL of PUBLIC HEALTH

Important Dates for the Academic Year

Fall 2016

Monday, August 29 - Friday, September 2	Orientation.
Tuesday, August 30 - Thursday, September 1	Registration for new and continuing students.
Monday, September 5	Labor Day (NO CLASSES).
Tuesday, September 6	First day of classes.
Tuesday, September 6 - Friday, September 16	Change of program period.* Late registration with fee.
Tuesday, November 8	Election Day (NO CLASSES).
Thursday, November 19	Last day to drop individual courses or change grading option.
Thursday, November 24 - Sunday, November 27	Thanksgiving holiday (NO CLASSES).
Monday, December 12	Last day of classes for the Fall term.
Monday, December 19 - Friday, December 23	Final exams. End of the Fall term.
Saturday, December 24 - Monday, January 16	Winter holiday (NO CLASSES).

Spring 2017

Tuesday, January 10 - Thursday, January 12	Registration for all students.
Monday, January 16	Martin Luther King, Jr. holiday (NO CLASSES).
Tuesday, January 17	First day of classes.
Tuesday, January 17 - Friday, January 27	Change of program period.* Late registration with fee.
Monday, February 20	President's Day (NO CLASSES).
Saturday, March 11 - Sunday, March 19	Spring Holidays (NO CLASSES).
Thursday, April 6	Last day to drop individual courses or change grading option.
Monday, May 1	Last day of classes for the Spring term.
Friday, May 5 - Friday, May 12	Final exams. End of the Spring term.
Tuesday, May 16	MSPH Commencement.
Wednesday, May 17	All University Commencement.

Summer 2017

Monday, May 22 - Friday, June 30	First summer session.
Wednesday, July 5 - Tuesday, August 15	Second summer session.

The full MSPH academic calendar can be found at: mailman.columbia.edu/people/current-students/academics/academic-calendar

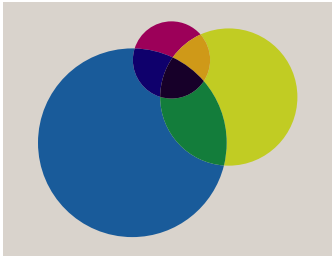
*** No adjustment of fees for individual courses dropped after this period.**

Message from the Chair

Welcome to the Department of Biostatistics at Columbia University's Mailman School of Public Health. Members of our faculty are national leaders in research, teaching, and service, addressing many of the most pressing public health and medical issues. Our research targets both the development of innovative biostatistical methods for study design and analysis as well as the application of biostatistical techniques in applied research. The field of biostatistics is rapidly evolving to address emerging areas involving the collection and analysis of massive, complex data sets. The big data era will prompt the development of new methods that are well suited for quantifying evidence, driving discovery, and enabling prediction from large-scale data. The Department of Biostatistics at Columbia has researchers who are advancing their respective areas of application by developing methods for the analysis of functional data, with particular expertise in genomics and brain imaging. We also have strengths in study design and data analysis for clinical trials. The Department thrives from collaborations across one of the world's most prestigious universities, renowned medical centers, and leading schools of public health. Our applied research leads to novel discoveries pertaining to cancer, HIV/AIDS, neurological and psychiatric disorders, cardiovascular health, and aging, among others.

The Department of Biostatistics at Columbia offers highly reputable graduate programs that provide excellent training for students in theory and methods, coupled with the applied experience necessary for professional practice. Employers recognize the high quality of our training programs, and our graduates receive premier jobs in academia, private sector, and government.

I am excited about the tremendous impact that Columbia faculty, staff, graduate students, and alumni continue to have on advancing the field of biostatistics and ultimately making vital contributions that improve the public's health and medical practice.



This visual representation of biostatistics allows us to describe our discipline through various intersections and overlaps. Biostatistics can be thought of as being at the intersection of science, art, and discovery. It can be thought of as the catalyst among interdisciplinary team members working together to solve a problem in public health or medicine. It also allows us to recall that systems are complex, and that our design and analytic approaches need to be developed within that context. The issues are usually more complex than we initially realize.

The Department of Biostatistics

Biostatistics is the science of developing and applying statistical methods for quantitative studies in biomedicine, health, and population sciences.

Biostatisticians play a crucial role in research design, collection and organization of data, analysis, presentation, and interpretation of results. Career opportunities are usually found in governmental agencies, private industry, and medical research institutions.

The Department of Biostatistics maintains collaborative relationships with other units of the University and with outside agencies and institutions. Among the many affiliated institutions and centers are: Columbia University Medical Center, New York State Psychiatric Institute, the Department of Statistics at Columbia's Morningside Campus, the Gertrude H. Sergievsky Center (research in the field of neuroepidemiology), the Herbert Irving Comprehensive Cancer Center and Institute of Cancer Research, the HIV Center for Clinical and Behavioral Studies, and the Irving Center for Clinical Research.

Faculty in the Department of Biostatistics work at the frontier of public health, leading research teams that investigate some of today's most pressing health issues. Recruited from the top universities from around the world, the faculty bring to the School a wealth of experience that serves to inform their research and teaching.

DUBOIS BOWMAN (PhD, University of North Carolina at Chapel Hill)
Department Chair, Professor of Biostatistics

Research interests: Development of biostatistical methods for brain imaging data, including functional magnetic resonance imaging, diffusion tensor imaging, and positron emission tomography

HOWARD ANDREWS (PhD, Rutgers University)
Associate Professor at CUMC of Neuroscience (in Biostatistics)

Research interests: Clinical trials, data management systems, multi-level analysis, perinatal outcomes, environmental factors, Alzheimer's disease

MELISSA D. BEGG (ScD, Harvard University)
Professor of Clinical Biostatistics, and Columbia University Vice Provost for Academic Programs

Research interests: Analysis of clustered data, oral health research, mental health statistics, clinical research training

QIXUAN CHEN (PhD, University of Michigan)
Assistant Professor of Biostatistics

Research interests: Bayesian inference for complex survey data, analysis of incomplete data, non-parametric regression, and random effects models

TAI-TSANG CHEN (PhD, Columbia University)
Adjunct Assistant Professor of Biostatistics

Research interests: Innovative clinical trial designs, longitudinal data analysis and causal inference in cancer studies

BIN CHENG (PhD, University of Wisconsin-Madison)
Associate Professor of Biostatistics

Research interests: Linear and generalized linear mixed models, statistical analysis of clinical trials, longitudinal non-normal data modeling, statistical computing, statistical inference on manifolds

YING-KUEN KENNETH CHEUNG (PhD, University of Wisconsin-Madison)
Professor of Biostatistics

Research interests: Design and analysis of clinical trials, methods in toxicology studies and bioassay, applications of Monte Carlo methods, nonparametric methods, bioethics

CODRUTA CHIUZAN (PhD, Medical University of South Carolina)
Associate Research Scientist

Research interests: Early adaptive clinical trial designs for cancer therapies, especially targeted and immunotherapeutic agents; survival analysis; statistical consulting

HANGA GALFALVY (PhD, University of Illinois)
Associate Professor of Biostatistics (in Psychiatry)

Research interests: Statistical methodology in psychiatric research, with a special focus on the prediction models for suicidal behavior from high-dimensional data, censored regression models, statistical genetics, and longitudinal data analysis in observational studies

JEFF GOLDSMITH (PhD, Johns Hopkins University)
Assistant Professor of Biostatistics

Research interests: Functional data analysis, high-dimensional regression, longitudinal data analysis, smoothing, Bayesian variable selection, neuroimaging, and accelerometry

PRAKASH GORROOCHURN (PhD, Monash University)
Associate Professor of Clinical Biostatistics

Research interests: Mathematical population genetics, genetic mapping of complex diseases

IULIANA IONITA-LAZA (PhD, New York University)
Associate Professor of Biostatistics

Research interests: Statistical genetics and bioinformatics

HAOMIAO JIA (PhD, Case Western University)
Associate Professor of Biostatistics (in Nursing)

Research interests: Small area estimation, data smoothing, temporal-spatial analysis, survey sampling

ZHEZHEN JIN (PhD, Columbia University)
Professor of Biostatistics

Research interests: Survival analysis, resampling methods, ROC curves, smoothing methods, nonparametric regression, clinical trials

SEONJOO LEE (PhD, University of North Carolina-Chapel Hill)
Assistant Professor of Clinical Biostatistics (in Psychiatry)

Research interests: Neuroimaging, cognitive neuroscience, machine learning, and functional data analysis

SHING M. LEE (PhD, Columbia University)
Assistant Professor of Clinical Biostatistics

Research interests: Rapid dose finding techniques in Phase I trials, and the development of more sensitive endpoints (e.g. Toxicity Burden Scores) in Phase I Trials

CHENG-SHIUN LEU (PhD, Columbia University)
Associate Professor of Clinical Biostatistics (in Psychiatry)

Research interests: Sequential selection procedures for multi-armed clinical trials, statistical application in behavioral studies

BRUCE LEVIN (PhD, Harvard University)
Professor of Biostatistics

Research interests: Analysis of categorical data, conditional likelihood analysis, sequential experimentation, reproductive epidemiology, statistics in the law, bioethics

GEN LI (PhD, University of North Carolina-Chapel Hill)
Assistant Professor of Biostatistics

Research interests: Statistical analysis of high dimensional data, functional data, and multi-source data; statistical genetics; bioinformatics

XINHUA LIU (PhD, Johns Hopkins University)
Professor of Clinical Biostatistics

Research interests: Statistical modeling, survival analysis, longitudinal data analysis, application of statistical methods in psychiatric, epidemiologic and environmental health science related research

SARA LOPEZ-PINTADO (PhD, University Carlos III of Madrid)
Assistant Professor of Biostatistics

Research interests: Functional data analysis, specifically functional depth and its applications to medicine, biology, and economics

CHRISTINE MAURO (PhD, Columbia University)
Associate Research Scientist

Research interests: Analysis of clinical trials, longitudinal data analysis, statistical learning techniques, and the application of statistics to problems in mental health research

IAN MCKEAGUE (PhD, University of North Carolina at Chapel Hill)
Professor of Biostatistics

Research interests: Survival analysis, competing risks in HIV/AIDS studies, inference for stochastic processes, empirical likelihood, Markov chain Monte Carlo, functional data analysis, semiparametric efficiency, Bayesian statistics, and martingale and counting process methods

TODD OGDEN (PhD, Texas A&M University)
Professor of Biostatistics (in Psychiatry)

Research interests: Analysis of brain imaging data, functional data analysis, nonparametric regression, wavelet applications, statistical modeling

MARTINA PAVLICOVA (PhD, Ohio State University)
Associate Professor of Clinical Biostatistics

Research interests: Functional magnetic resonance imaging, multiple comparisons methods, spatial statistics

MIN QIAN (PhD, University of Michigan)
Assistant Professor of Biostatistics

Research interests: Medical decision making, dynamic treatment regimes, variable selection/model selection for decision making, statistical machine learning, reinforcement learning, statistical inference, bootstrap, empirical processes, concentration inequalities, stochastic processes

ARINDAM ROYCHOUDHURY (PhD, University of Washington)
Assistant Professor of Biostatistics

Research interests: Statistical genetics focusing on population genetics, phylogenetics, and association mapping

MING-XIN TANG (PhD, Columbia University)
Associate Professor of Clinical Biostatistics (in the Sergievsky Center)

Research interests: Survival analysis, statistical applications in biomedical and public health sciences

JOHN L.P. (SEAMUS) THOMPSON (PhD, University of California-Los Angeles)
Clinical Professor of Biostatistics and Neurology

Research interests: Randomized clinical trials, trial design, neurology, data management systems

WEI-YANN TSAI (PhD, University of Wisconsin-Madison)
Professor of Biostatistics

Research interests: Survival analysis, incomplete data methods, nonparametrics

ROGER D. VAUGHAN (DrPH, Columbia University)
Professor of Clinical Biostatistics, and Vice Dean for Academic Advancement

Research interests: Analysis of data arising from group randomized trials and from quasi-experiments, analysis of clustered or correlated binary data, program evaluation

MELANIE WALL (PhD, Iowa State University)
Professor of Biostatistics (in Psychiatry)

Research interests: Latent variable modeling, spatial, and longitudinal data analysis

SHUANG WANG (PhD, Yale University)
Associate Professor of Biostatistics

Research interests: Statistical genetics, genetic epidemiology, quantitative trait loci analysis

YUANJIA WANG (PhD, Columbia University)
Associate Professor of Biostatistics

Research interests: Statistical analysis of genetic data, semiparametric efficiency, high-dimensional data analysis, functional data analysis

YING WEI (PhD, University of Illinois-Urbana Champaign)
Associate Professor of Biostatistics

Research interests: Quantile regression methods, growth charts estimation, longitudinal data analysis, semiparametric modeling, and robust statistics

PRIYA J. WICKRAMARATNE (PhD, Yale University)
Associate Professor of Clinical Biostatistics

Research interests: Epidemiologic methods, observational studies, survival analysis, generalized linear models, psychiatric epidemiology

The Accelerated MPH

Director: Shuang Wang, PhD

The Accelerated Masters in Public Health in Biostatistics (MPH) is an intensive, one-year program designed for highly motivated professionals seeking to enhance their career with a degree in public health. MPH students will receive a strong general public health orientation and specific training in quantitative methods, enabling them to use and adapt statistical procedures in the design and analysis of studies spanning the spectrum of health-related research.

Course Requirements

The structure of the one-year degree program includes five components, which are all carefully timed and integrated so that learning in one part of the program informs activities and assignments in another:

1. **Discipline** - courses required by your home department
2. **Core** - curriculum that provides the broad, interlocking foundation of knowledge needed for a career in public health
3. **Integration of Science and Practice** - course that bridges the gap between what you traditionally learn in a classroom and the real-world experience of working as a public health professional
4. **Leadership & Innovation** - course that aims to develop and improve MPH students' abilities in three key areas: leading teams in a variety of settings, working effectively as a team member, and implementing fresh, innovative ideas within an organization or larger community.
5. **Practicum and Capstone Paper** - internship in the field with final paper.

Practicum and Capstone Paper

The practicum—essentially an internship in the field—is a required component of an MPH degree. During the practicum, the student will work alongside public health professionals, experience the day-to-day realities of the field and have the opportunity to apply concepts learned in class to make an active contribution in public health. Accelerated MPH students have the option of a client-based practicum in which a few students work together as consultants for one organization—perhaps a domestic or international NGO or health department—on a particular issue. Some Accelerated MPH students may be able to create a practicum experience within the context of their job. Practicums may be scheduled during the winter intersession, the summer, or over an extended multi-semester timetable. Upon completion of the practicum, each student will complete a capstone paper which details his/her role, how data was managed, the specific statistical methods and key types of measures used on the study, and any outcomes of the project.

Curriculum

Required Discipline Courses		Points
P8100	Applied Regression I *(Spring)*	3
P8110	Applied Regression II *(Summer)*	3
P8120	Analysis of Categorical Data *(Spring)*	3
P8140	Introduction to Randomized Clinical Trials *(Spring)*	3
P8180	Research Data Coordination: Principles and Practices *(Fall)*	3

Elective Courses *Choose 2 or more courses from this list or from alternatives approved by your academic advisor.*		Points
P6110	Statistical Computing in SAS	3
P8114	Statistical Issues in Microarray Data	1
P8142	Clinical Trial Methodology	3
P8144	Pharmaceutical Statistics	3
P8150	Seminar in Topics in Applied Statistics	3
P8157	Analysis of Longitudinal Data	3
P8158	Latent Variable and Structural Equation Modeling for Health Sciences	3
P8160	Topics in Advanced Statistical Computing	3
P8482	Outcomes Research: Methods and Public Health Implications	3

Timeline

Fall	Spring	Summer
Core	Integration of Science and Practice	P8110 Applied Regression II
Integration of Science and Practice	Leadership and Innovation	Capstone
P8180: Research Data Coordination	P8100 Applied Regression I	Practicum (suggested time frame)
	P8120 Analysis of Categorical Data	Elective(s)
	P8140 Introduction to RCTs	
	Elective(s)	

Master of Science degree programs

The Department of Biostatistics offers two Master of Science degree programs: the MS in Biostatistics and the MS in Patient Oriented Research.

Students pursuing the MS in Biostatistics degree select one of four tracks of specialization: Clinical Research Methods, Pharmaceutical Statistics, Statistical Genetics, and Theory & Methods. The MS in Patient Oriented Research degree program is also housed in the department. Whether the focus of the degree is to prepare for doctoral research training, to advance the skills critical for clinical scientists, or as a biostatistician in public health or the pharmaceutical industry, both programs require a facility for quantitative reasoning and a true enjoyment of working with data.

Upon satisfactory completion of the MS in Biostatistics or the MS in Patient Oriented Research, graduates will be able to:

Data Analysis and Computing

- Formulate and produce graphical displays of quantitative information (e.g., scatter plots, box plots, line graphs) that effectively communicate analytic findings;
- Explain general principles of study design in attempting to identify risk factors for disease, isolate targets for prevention, and assess the effectiveness of one or more interventions;
- Select and perform appropriate hypothesis tests for comparing two or more independent exposure groups, or two or more groups of matched/clustered subjects, with respect to a discrete or continuous response measurement of interest;
- Interpret associations estimated via linear regression, logistic regression, and Cox models for survival data;
- Apply the basic tenets of research design and analysis for the purpose of critically reviewing research and programs in disciplines outside of biostatistics; and
- Interpret quantitative findings in accurate, accessible language for colleagues outside of biostatistics, as well as for broader dissemination to the public and other public health professionals.

Public Health and Collaborative Research

- Translate research objectives into testable hypotheses;
- Compare and contrast different study designs and their implications for inference in medical/public health research;
- Describe basic principles and the practical importance of key concepts from probability and inference (including random variation, systematic error, sampling error, measurement error, hypothesis testing, type I and type II errors, confounding bias, and effect modification) to colleagues without extensive statistical training;
- Develop and execute power and sample size calculations for research studies utilizing simple random sampling; and
- Evaluate research reports and proposals for research funding on the basis of their scientific integrity, validity, and the strength of the quantitative analysis.

A brief comparison of the MS Degree Programs

Degree Program	Track	Minimum Credits	Typical Duration	Practicum	Capstone
Master of Science in Biostatistics	Clinical Research Methods Track (MS/CRM)	30	5 semesters (including summer)	No	Yes
Master of Science in Biostatistics	Pharmaceutical Statistics Track (MS/PS)	35	4 semesters	Yes	Yes
Master of Science in Biostatistics	Statistical Genetics Track (MS/SG)	36	4 semesters	Yes	Yes
Master of Science in Biostatistics	Theory and Methods Track (MS/TM)	36	4 semesters	Yes	Yes
Master of Science in Patient Oriented Research	Patient Oriented Research Program (MS-POR)	30	5 semesters (including summer)	No	Yes

Clinical Research Methods Track

Director: Roger D. Vaughan, DrPH

The Master of Science in Biostatistics degree program - Clinical Research Methods track (MS/CRM) provides formal, rigorous training in skills critical to the design and analysis of clinically oriented research studies. It is intended for physicians, nurses, dentists, psychologists, pharmacists, and other health care professionals who plan careers or are actively engaged in clinical research. MS/CRM students will hone their quantitative talents to better pursue research objectives in their chosen fields. As the level of competitiveness for limited research support increases, it is now more important than ever to develop a well-designed study with a strong analytic plan. Mastery of applied biostatistical methods improves the likelihood of assembling compelling and effective clinical research projects and promoting good research practices.

Course Requirements

The required courses are intended to enable degree candidates to gain proficiency in study design, application of commonly-used statistical procedures, facility with statistical software packages, and ability to successfully interpret and communicate the results of an analysis. Students must complete a minimum of 30 points to earn the MS/CRM degree, of which 24 points must be taken at the Mailman School of Public Health. *Up to two electives may be taken pass/fail, especially to encourage students to take courses outside their field of experience.*

Note that some courses in the required curriculum may be waived based on prior coursework with approval of faculty advisor. In this event, the student may substitute another, more advanced course in place of the waived course. Students interested in completing the program in 1.5 years, are strongly advised to begin coursework by enrolling in the **Columbia Summer Research Institute** which allows students to complete 10 credits over 5 weeks. In a second summer session, students may earn another 10 credits over 5 weeks.

Students' progress will be reviewed after each semester. Those students whose academic performance falls below a B average (3.0 GPA) in required courses may not be allowed to graduate without remedial course work.

Capstone Experience

As part of the MS/CRM training, each student is required to enroll in P9160 Master's Essay—Clinical Research Methods. This research component of the MS/CRM program should be completed during the final year of study. Conducted in workshop style, students in this course will participate in a weekly seminar geared towards enhancing research skills. At the end of the term, each student will be required to submit a research paper of publishable quality, summarizing his or her research project. Students planning on taking P9160 should have a data set of interest available to them; you must ensure that you have permission (and IRB approval) to analyze and publish results from your analysis. Most sessions will be devoted to discussion of the individual research projects and related current literature. Other times, active researchers from biostatistics and various clinical disciplines may be invited to speak on research techniques, statistical methodology as applied in current studies, and their experiences in conducting patient oriented research. Students will present their topics, plans for analysis, and interpretation of their findings to the class for evaluation and feedback. The completion and submission of this research paper satisfies the student's practicum requirement.

Curriculum (TOTAL POINTS: 30 OR MORE)

Required Courses		Points
P6104	Introduction to Biostatistical Methods *(Summer, Fall)*	3
P6400	Principles of Epidemiology *(Fall)*	3
P8100	Applied Regression I *(Fall, Spring)*	3
P8110	Applied Regression II *(Spring, Summer)*	3
P8120	Analysis of Categorical Data *(Fall, Spring)*	3
P8140	Introduction to Randomized Clinical Trials *(Fall, Spring)*	3
P8438	Epidemiology II: Design and Conduct of Observational Epidemiology *(Spring)*	3
P9160	Master's Essay - Clinical Research Methods *(Spring)*	3

Elective Courses *Choose 2 or more courses from this list or from alternatives approved by your academic advisor.*		Points
P6110	Statistical Computing with SAS	3
P6530	Issues and Approaches in Health Policy and Management	3
P8104	Probability	3
P8109	Statistical Inference	3
P8142	Clinical Trial Methodology	3
P8144	Pharmaceutical Statistics	3
P8149	Statistical Aspects of Human Population Genetics	3
P8157	Analysis of Longitudinal Data	3
P8158	Latent Variable and Structural Equation Modeling for Health Sciences	3
P8180	Research Data Coordination: Principles and Practices	3
P8307	Molecular Epidemiology	3
P8308	Molecular Toxicology	3
P8404	Epidemiology of Genetics and Aging	3
P8405	Genetics in Epidemiology	3
P8406	Epidemiology of Infections Diseases I	3
P8414	Cancer Epidemiology	3
P8417	Selected Problems of Measurement in Epidemiology	3
P8432	Environmental Epidemiology	3
P8440	Epidemiology of Cardiovascular Diseases	3
P8482	Outcomes Research: Methods and Public Health Implications	3

Sample Timeline

Summer I	Fall I	Spring I	Fall II	Spring II
P6104 Introduction to Biostatistical Methods	P8100 Applied Regression I	P8110 Applied Regression II	P8120 Analysis of Categorical Data	P8438 Epidemiology II
Elective	P6400 Principles of Epidemiology I	P8140 Introduction to RCTs	Elective	P9160 Master's Essay

Sample Timeline for summer-intensive & goal-directed coursework

Summer I (10 credits in 5 weeks)	Fall I	Spring I	Summer II (10 credits in 5 weeks)	Fall II
P6104 Intro to Biostatistical Methods	P8100 Applied Regression I	P8120 Analysis of Categorical Data	P8110 Applied Regression II	P9161 Master's Essay II (3 credits)
P6400 Principles of Epidemiology I	P9161 Master's Essay II (0.5 credits)	P9161 Master's Essay II (0.5 credits)	P8140 Introduction to RCTs	
P8182 Writing a Successful NIH Grant			P8545 Analysis of Large Scale Data Sets	
P8568 Decision Analysis			P8112 Systematic Review and Meta-analysis	
P8750 Race and Health			P9161 Master's Essay II (1 credit)	
KEY DELIVERABLES outline for NIH grant proposal	Draft outline for a full research article to be submitted to a peer-reviewed journal		peer-critiqued final outline for NIH grant proposal	NIH grant proposal for February submission; Full research article submitted

Pharmaceutical Statistics

Director: Ken Cheung, PhD

The Master of Science in Biostatistics degree program - Pharmaceutical Statistics track (MS/PS) provides study design, research, and biostatistics skills to individuals who are currently working in the pharmaceutical research industry and those seeking to begin a career in the industry. MS/PS students will understand the challenges and modern methods relevant to translational research and clinical trials.

Course Requirements

Students must complete a minimum of 35 credits of coursework to earn the MS/PS degree, of which 30 points must be taken at the Mailman School of Public Health. *Up to two electives may be taken pass/fail, especially to encourage students to take courses outside their field of experience.*

Note that some courses in the required curriculum may be waived based on prior coursework with approval of faculty advisor. In this event, the student may substitute another, more advanced course in place of the waived course.

Students' progress will be reviewed after each semester. Those students whose academic performance falls below a B average (3.0 GPA) in required courses may not be allowed to graduate without remedial course work.

Practicum Requirement

One term of practical experience is required of all students, providing educational opportunities that are different from and supplementary to the more academic aspects of the program. The practicum may be fulfilled during the school year or over the summer. Arrangements are made on an individual basis in consultation with faculty advisors who must approve both the proposed practicum project prior to its initiation, and the report submitted at the conclusion of the practicum experience. Students will be required to make a poster presentation at the department's Annual Practicum Poster Symposium which is held in early May. See the practicum information section at the back of the handbook for details and links to required forms.

Capstone Experience (REQUIRED FOR STUDENTS WITHOUT INDUSTRY EXPERIENCE)

A formal culminating experience is required for graduation. The capstone consulting experience is designed to enable students to demonstrate their ability to integrate their academic studies with the role of biostatistical consultant/collaborator, which will comprise the major portion of their future professional practice. After completing a minimum of 15 credits of required coursework, students register for P8185 Capstone Consulting Seminar, a one-semester, one-credit course. Students are required to attend at least one session of the Biostatistics Consulting Service, run by faculty in the Department of Biostatistics and present the consult to the class for discussion. The Consulting Service offers advice on data analysis and appropriate methods of data presentation for publications, and provides design recommendations for public health and clinical research, including preparation of grant proposals and manuscripts. Operating five days a week, the Consulting Service is a free biostatistical resource for public health and other health sciences researchers at Columbia University.

Curriculum (TOTAL POINTS: 35 OR MORE)

Required Courses		Points
P6104	Introduction to Biostatistical Methods *(Summer, Fall)*	3
P6110	Statistical Computing with SAS *(Fall, Spring)*	3
P6170	New Drug Development: A Regulatory Overview *(Spring)*	3
P6400	Principles of Epidemiology *(Fall)*	3
P8120	Analysis of Categorical Data *(Fall, Spring)*	3
P8140	Introduction to Randomized Clinical Trials *(Fall, Spring)*	3
P8142 *	Clinical Trial Methodology *(Fall)*	3
P8144	Pharmaceutical Statistics *(Spring)*	3
P8180	Research Data Coordination: Principles and Practices *(Fall, Spring)*	3
P8185 †	Capstone Consulting Seminar *(Spring)*	1

Elective Courses *Choose 2 or more courses from this list or from alternatives approved by your academic advisor.*		Points
P6503	Introduction to Health Economics	3
P8100	Applied Regression I	3
P8104 †	Probability	3
P8109 **	Statistical Inference	3
P8111 **	Linear Regression Models	
P8116	Design of Medical Experiments	3
P8133	Adaptive Designs for Clinical Trials	3
P8134	Stochastic Approximation and Modern Dose-Finding	3
P8401	Pharmacoepidemiology	3
G4010	Responsible Conduct of Research and Related Policy Issues	1
GU4200	Biopharmaceutical Development and Regulation	3
W4201	Seminar in Biopharmaceutical Development and Regulation	3

* *P8142 may be replaced by P8133, which requires P8104 and P8109*
** *Very strongly suggested elective for students without industry experience*
† *Required for students without industry experience*

Sample Timeline for students with industry experience

Fall I	Spring I	Fall II	Spring II
P6104 Introduction to Biostatistical Methods	P6170 New Drug Development	P8120 Analysis of Categorical Data	P8144 Pharmaceutical Statistics
P6110 Statistical Computing in SAS	P8140 Introduction to RCTs	P8142 Clinical Trial Methodology *(or P8133 Adaptive Designs)*	
P6400 Principles of Epidemiology I	Elective	P8180 Research Data Coordination	
	Elective	Elective	

Sample Timeline for students without industry experience

Fall I	Spring I	Fall II	Spring II
P6104 Introduction to Biostatistical Methods	P6170 New Drug Development	P6110 Statistical Computing in SAS	P8144 Pharmaceutical Statistics
P6400 Principles of Epidemiology I	P8140 Introduction to RCTs	P8120 Analysis of Categorical Data	P8185 Capstone Consulting Seminar
P8104 Probability	Elective - *strongly suggested: P8109 Statistical Inference*	P8142 Clinical Trial Methodology *(or P8133 Adaptive Designs)*	
	Elective - *strongly suggested: P8111 Linear Regression Models*	P8180 Research Data Coordination	

Statistical Genetics

Director: Prakash Gorroochurn, PhD

The Master of Science in Biostatistics degree program - Statistical Genetics track (MS/SG) prepares well qualified students to use advanced modern statistical genetic methods to dissect complicated human genetic archeology with cutting-edge technologies. The high powered curriculum keeps pace with the fast developing field of statistical genetics. Students begin with a rigorous grounding in statistical theory and practice, and then incorporate modern analytic methods into their tool box via new coursework. Students are exposed to the rapidly evolving implementation of those methods in both the hands on practicum experience and consulting work, and in Journal Club reviews of modern methods presented and applied in the literature

Course Requirements

MS/SG students are expected to gain proficiency in genetic study design and analysis as represented by the courses listed below. Students must complete a minimum of 36 academic credits to earn the MS/SG degree, of which 30 points must be taken at the Mailman School of Public Health. Up to two electives may be taken pass/fail, especially to encourage students to take courses outside their field of experience.

Note that some courses in the required curriculum may be waived based on prior coursework with approval of faculty advisor. In this event, the student may substitute another, more advanced course in place of the waived course.

Students' progress will be reviewed after each semester. Those students whose academic performance falls below a B average (3.0 GPA) in required courses may not be allowed to graduate without remedial course work.

A student is considered full-time in the MS/SG program if he or she takes a minimum of 12 credits per semester. **International students are required to be registered for at least 12 credits during their second and third semesters.**

Practicum Requirement

One term of practical experience is required of all students, providing educational opportunities that are different from and supplementary to the more academic aspects of the program. The practicum may be fulfilled during the school year or over the summer. Arrangements are made on an individual basis in consultation with faculty advisors who must approve both the proposed practicum project prior to its initiation, and the report submitted at the conclusion of the practicum experience. Students will be required to make a poster presentation at the department's Annual Practicum Poster Symposium which is held in early May. See the practicum information section at the back of the handbook for details and links to required forms.

Capstone Experience

A formal culminating experience is required for graduation. The capstone consulting experience is designed to enable students to demonstrate their ability to integrate their academic studies with the role of biostatistical consultant/collaborator, which will comprise the major portion of their future professional practice. After completing a minimum of 15 credits of required coursework, students register for P8185 Capstone Consulting Seminar, a one-semester, one-credit course. Students are required to attend at least one session of the Biostatistics Consulting Service, run by faculty in the Department of Biostatistics and present the consult to the class for discussion. The Consulting Service offers advice on data analysis and appropriate methods of data presentation for publications, and provides design recommendations for public health and clinical research, including preparation of grant proposals and manuscripts. Operating five days a week, the Consulting Service is a free biostatistical resource for public health and other health sciences researchers at Columbia University.

Curriculum (TOTAL POINTS: 36 OR MORE)

Required Courses

Core Biostatistics Courses		Points
P6104	Introduction to Biostatistical Methods *(Summer, Fall)*	3
P6400	Principles of Epidemiology *(Fall)*	3
P8104	Probability *(Fall)*	3
P8109	Statistical Inference *(Fall)*	3
P8111	Linear Regression Models *(Spring)*	3
P8120	Analysis of Categorical Data *(Fall, Spring)*	3
P8121	Generalized Linear Models *(Fall)*	3
Core Genetics Courses		
P8119	Advanced Statistical and Computational Methods in Genetics and Genomics	3
P8139	Statistical Genetics Modeling	3
P8149	Statistical Population Genetics	3
P8163	Statistical Genetics Journal Club *(Spring II)*	1
P8185	Capstone Consulting Seminar	1

Elective Courses

Choose 2 or more courses from this list or from alternatives approved by your academic advisor.

		Points
COMS W1003	Introduction to Computer Science and Programming in C	3
CBMF W4761	Computational Genomics	3
COMS W4771	Machine Learning	3
P8160	Topics in Advnaced Statistical Computing	3
P8405	Genetics in Epidemiology	3
P8438	Epidemiology II: Design and Conduct of Observational Epidemiology	3
W4606	Elementary Stochastic Processes	3

Sample Timeline

Fall I	Spring I	Fall II	Spring II
P6104 Introduction to Biostatistical Methods	P8109 Statistical Inference	P8121 Generalized Linear Models	P8139 Statistical Genetics Modeling
P6400 Principles of Epidemiology I	P8111 Linear Regression Models	P8149 Statistical Population Genetics	P8163 Statistical Genetics Journal Club
P8104 Probability	P8119 Advanced Statistical & Computational Methods	Elective	P8185 Capstone Consulting Seminar
	P8120 Analysis of Categorical Data	Elective	

Theory and Methods

Director: R. Todd Ogden, PhD

The Master of Science in Biostatistics degree program - Theory and Methods track (MS/TM) is designed to prepare individuals for a career applying statistical methods in the biomedical sciences. The MS/TM program is the appropriate program for a student whose goal is to work effectively as a biostatistician in a biomedical, clinical, or laboratory research setting; or for a student who plans to pursue a PhD in biostatistics.

Course Requirements

MS/TM students are expected to master certain mathematical and biostatistical concepts and techniques as represented by the courses listed below. Students must complete a minimum of 36 points to earn the MS/TM degree, of which 30 points must be taken at the Mailman School of Public Health. *Up to two electives may be taken pass/fail, especially to encourage students to take courses outside their field of experience.*

Note that some courses in the required curriculum may be waived based on prior coursework with approval of faculty advisor. In this event, the student may substitute another, more advanced course in place of the waived course.

Students' progress will be reviewed after each semester. Those students whose academic performance falls below a B average (3.0 GPA) in required courses may not be allowed to graduate without remedial course work.

A student is considered full-time in the MS/TM program if he or she takes a minimum of 12 credits per semester. **International students are required to be registered for at least 12 credits during their second and third semesters.**

Practicum Requirement

One term of practical experience is required of all students, providing educational opportunities that are different from and supplementary to the more academic aspects of the program. The practicum may be fulfilled during the school year or over the summer. Arrangements are made on an individual basis in consultation with faculty advisors who must approve both the proposed practicum project prior to its initiation, and the report submitted at the conclusion of the practicum experience. Students will be required to make a poster presentation at the department's Annual Practicum Poster Symposium which is held in early May. See the practicum information section at the back of the handbook for details and links to required forms.

Capstone Experience

A formal culminating experience is required for graduation. The capstone consulting experience is designed to enable students to demonstrate their ability to integrate their academic studies with the role of biostatistical consultant/collaborator, which will comprise the major portion of their future professional practice. After completing a minimum of 15 credits of required coursework, students register for P8185 Capstone Consulting Seminar, a one-semester, one-credit course. Students are required to attend at least one session of the Biostatistics Consulting Service, run by faculty in the Department of Biostatistics and present the consult to the class for discussion. The Consulting Service offers advice on data analysis and appropriate methods of data presentation for publications, and provides design recommendations for public health and clinical research, including preparation of grant proposals and manuscripts. Operating five days a week, the Consulting Service is a free biostatistical resource for public health and other health sciences researchers at Columbia University.

Curriculum (TOTAL POINTS: 36 OR MORE)

Required Courses		Points
P6104	Introduction to Biostatistical Methods *(Summer, Fall)*	3
P6400	Principles of Epidemiology *(Fall)*	3
P8104	Probability *(Fall)*	3
P8108	Survival Analysis *(Fall)*	3
P8109	Statistical Inference *(Fall)*	3
P8111	Linear Regression Models *(Spring)*	3
P8116	Design of Medical Experiments *(Spring)*	3
P8120	Analysis of Categorical Data *(Fall, Spring)*	3
P8121	Generalized Linear Models *(Fall)*	3
P8140	Introduction to Randomized Clinical Trials *(Fall, Spring)*	3
P8185	Capstone Consulting Seminar *(Spring)*	1

Elective Courses *Choose 2 or more courses from this list or from alternatives approved by your academic advisor.*		Points
P6110	Statistical Computing with SAS	3
P8114	Statistical Issues in Microarray Data	1
P8142	Clinical Trial Methodology	3
P8144	Pharmaceutical Statistics	3
P8150	Seminar in Topics in Applied Statistics	3
P8157	Analysis of Longitudinal Data	3
P8158	Latent Variable and Structural Equation Modeling for Health Sciences	3
P8160	Topics in Advanced Statistical Computing	3
P8180	Research Data Coordination: Principles and Practices	3
P8482	Outcomes Research: Methods and Public Health Implications	3
G4001	Introduction to Computer Applications in Health Care Biomedicine	3
W4606	Elementary Stochastic Processes *(Morningside Campus)*	3

Please note P8100 and P8110 cannot be counted towards the MS/TM track.

Sample Timeline

Fall I	Spring I	Fall II	Spring II
P6104 Introduction to Biostatistical Methods	P8109 Statistical Inference	P8108 Survival Analysis	P8116 Design of Medical Experiments
P6400 Principles of Epidemiology I	P8111 Linear Regression Models	P8121 Generalized Linear Models	P8185 Capstone Consulting Seminar
P8104 Probability	P8120 Analysis of Categorical Data	Elective	
	P8140 Introduction to RCTs	Elective	

Patient Oriented Research

Director: Melissa D. Begg, ScD

The Master of Science in Patient Oriented Research (MS-POR) degree program provides training in the fundamentals of clinical and translational investigation, with a view to enabling young researchers to compete more effectively for research funding. MS/POR students are trained in the design, conduct, and evaluation of clinical research studies, with close supervision and support from the Program Director.

The program is comprised of an interdisciplinary series of courses and colloquia that reflects both the public health faculty's expertise in design and conduct of research studies and the clinical faculty's intimate knowledge of human health and patient care.

Course Requirements

The required courses are intended to enable degree candidates to gain proficiency in study design, application of commonly-used statistical procedures, facility with statistical software packages, and ability to successfully interpret and communicate the results of an analysis. The overall goal is to make graduates more competitive in pursuit of research funding. The two-year MS-POR curriculum consists of 30 credits in total and a culminating Master's Essay.

MS-POR candidates must begin study during their first summer by enrolling in the **Columbia Summer Research Institute** (CSRI). In the CSRI, students will earn 10 credits over ~5 weeks of full-time effort, completing two introductory-level required courses (epidemiology and biostatistics) and two mini-electives (health disparities research and decision/cost-effectiveness analysis). Students earn one-third of the required credits in the first summer, leaving greater flexibility and fewer scheduling commitments over the following 21 months.

Note that some courses in the required curriculum may be waived based on prior coursework with approval of faculty advisor. In this event, the student may substitute another, more advanced course in place of the waived course.

Any student whose GPA falls below a B average (3.00) will be required to meet with his/her academic advisor to discuss remedial measures before continuing in the program.

Capstone Experience

As part of the MS/POR training, each student is required to register for Public Health P9165 Master's Essay – Patient Oriented Research, and complete a master's essay consisting of the construction of an NIH-style grant application. The student is supervised by a Project Sponsor from biostatistics and by a clinical mentor from the student's own field of expertise. At the end of the term, each student will submit a research grant proposal, following NIH guidelines for applications. Each proposal is reviewed by the student's sponsors, followed by a formal presentation to the POR Advisory Board. The completion, submission, and presentation of the research proposal fulfill the practicum requirement.

Curriculum (TOTAL POINTS: 30 OR MORE)

Required Courses		Points
P6104	Introduction to Biostatistical Methods *(Summer)*	3
P6400	Principles of Epidemiology *(Summer)*	3
P8102	Basic Laboratory Methods *(Fall)*	1
P8103	Colloquium on Patient Oriented Research *(taken over four semesters) (Fall, Spring)*	2
P8120	Analysis of Categorical Data *(Fall, Spring)*	3
P8182	Writing a Successful Grant Application *(Summer)*	1
P8568	Decision Analysis for Clinical and Public Health *(Summer)*	2
P8750	Race and Health *(Summer)*	1
P9165	Master's Essay - Patient Oriented Research *(Fall)*	0
G4010	Responsible Conduct of Research and Related Policy Issues *(Spring)*	1
M9780	Funding for Research Activities: Basic Issues in Obtaining Support *(Spring)*	1
89260	Building Interdisciplinary Research Models *(also G9260 or N9260) (Spring)*	2

Restricted Elective Courses *Students are required to take **at least one** of the courses from this list.*		Points
P6385	Principles of Genetics and the Environment *(Fall)*	3
P8119	Adv Statistical & Computational Methods in Genetics & Genomics *(Spring)*	3
P8180	Research Data Coordination: Principles and Practices *(Fall)*	3
P8307	Molecular Epidemiology *(Spring)*	3
P8308	Molecular Toxicology *(Spring)*	3
P8319	Biological Markers of Chemical Exposure *(Fall)*	3
P8405	Genetics in Epidemiology *(Fall)*	3
P8771	Community Based Participatory Research *(Fall, Spring)*	3
G4001	Introduction to Computer Applications in Health Care & Biomedicine *(Fall)*	3
G4500	Cancer Biology I *(Fall)*	3
G6003	Mechanisms in Human Disease I *(Fall)*	4.5
G6004	Mechanisms in Human Disease II *(Spring)*	2

MSPOR elective courses continued on next page

curriculum CONTINUED

Elective Courses. Choose 4-5 courses from the lists below, or from the list of restricted electives on the previous page. Courses are grouped according to particular fields of emphasis. Students may select two or more courses from a certain grouping or from different groups, depending upon their interests. All selections must be approved by the student's supervisor.

Electives in Clinical Research

Electives in Biostatistics		**Points**
P6110	Statistical Computing with SAS	3
P8100	Applied Regression I	3
P8110	Applied Regression II	3
P8140	Introduction to Randomized Clinical Trials	3
P8142	Clinical Trial Methodology	3
P8144	Pharmaceutical Statistics	3
Electives in Epidemiology		
P8404	Epidemiology of Genetics and Aging	3
P8406	Epidemiology of Infectious Diseases I	3
P8414	Cancer Epidemiology	3
P8417	Selected Problems of Measurement in Epidemiology	3
P8432	Environmental Epidemiology	3
P8438/9	Epidemiology II: Design and Conduct of Observational Epidemiology	3
P8450	Clinical Epidemiology	3
Electives in Health Policy		
P6503	Introduction to Health Economics	3
P6530	Issues and Approaches in Health Policy and Management	3
P8541	Cost-benefit Analysis and Health	3

Electives in Translational Research

Electives in Environmental Health Sciences		**Points**
P6330	Radiation Science	3
P8312	Fundamentals of Toxicology	3
P8307	Molecular Epidemiology	3
P8308	Molecular Toxicology	3
P8319	Biological Markers of Chemical Exposure	3
Electives in the Graduate School of Arts and Sciences		
W4008	Cellular Physiology of Disease	3

Sample Timeline

Summer I	Fall I	Spring I	Fall II	Spring II
P6104 Intro to Biostatistical Methods	P8103 Colloquium (0.5)	P8103 Colloquium (0.5)	P8103 Colloquium (0.5)	P8103 Colloquium (0.5)
P6400 Principles of Epidemiology I	P8102 Basic Lab Methods	P8120 Analysis of Categorical Data	Elective	M9780 Funding for Research Activities
P8182 Writing a Successful NIH Grant	Elective	G4010 Responsible Conduct of Research	P9165 Master's Essay (POR Capstone)	
P8568 Decision Analysis		Elective		
P8750 Race and Health				

Doctoral degree programs

The Department of Biostatistics offers two doctoral degree programs: the Doctor of Public Health (DrPH) and the Doctor of Philosophy (PhD). Both the DrPH and PhD programs train candidates to apply state-of-the art statistical methods to the analysis of important public health issues and potential solutions, but differ in their relative emphasis on application versus statistical theory.

Doctor of Public Health (DrPH)

DrPH training places greater emphasis on the application of statistical methods to public health problems, although many DrPH students propose new methods and contribute to the advancement of statistical theory as part of their dissertation research.

Upon satisfactory completion of the DrPH degree in Biostatistics, graduates will be able to:

Data Analysis and Computing

- Identify and implement advanced statistical models for the purposes of estimation, comparison, prediction, and adjustment in non-standard settings.

Public Health and Collaborative Research

- Describe the foundations of public health, including the biological, environmental, behavioral, and policy factors that affect the health of populations;
- Develop and execute calculations for power and sample size when planning research studies with complex sampling schemes; and
- Formulate and prepare a written statistical plan for analysis of public health research data that clearly reflects the research hypotheses of the proposal in a manner that resonates with both co-investigators and peer reviewers.

Data Management

- Identify the uses to which data management can be put in practical statistical analysis, including the establishment of standards for documentation, archiving, auditing, and confidentiality; guidelines for accessibility; security; structural issues; and data cleaning;
- Differentiate between analytical and data management functions through knowledge of the role and functions of databases, different types of data storage, and the advantages and limitations of rigorous database systems in conjunction with statistical tools; and
- Assess database tools and the database functions of statistical software, with a view to explaining the impact of data management processes and procedures on their own research.

Teaching

- Review and illustrate selected principles of study design, probability theory, estimation, hypothesis testing, and data analytic techniques to public health students enrolled in first and second level graduate public health courses; and
- Explain advanced concepts in the theory of statistical inference to graduate students in biostatistics and mathematical statistics.

Biostatistical Research

- Identify and integrate new developments in the statistical literature for challenging research problems in public health; and
- Generate original computer code for new statistical techniques.

Doctor of Philosophy (PhD)

PhD training places relatively greater emphasis on the development of statistical theory and methods (or "theorem proving"). A PhD dissertation must represent an original contribution to statistical theory or methods that also has relevance to a real biomedical or public health application.

Upon satisfactory completion of the PhD degree in Biostatistics, graduates will be able to:

Data Analysis and Computing

- Identify and implement advanced statistical models for the purposes of estimation, comparison, prediction, and adjustment in non-standard settings.

Public Health and Collaborative Research

- Develop and execute calculations for power and sample size when planning research studies with complex sampling schemes;
- Formulate and prepare a written statistical plan for analysis of public health research data that clearly reflects the research hypotheses of the proposal in a manner that resonates with both co-investigators and peer reviewers; and
- Evaluate research reports and proposals for research funding on the basis of their scientific integrity, validity, and the strength of the quantitative analysis.

Consulting

- Function as an effective consultant in biomedical and public health research projects; and
- Develop communication and writing skills in a consulting environment.

Data Management

- Identify the uses to which data management can be put in practical statistical analysis, including the establishment of standards for documentation, archiving, auditing, and confidentiality; guidelines for accessibility; security; structural issues; and data cleaning;
- Differentiate between analytical and data management functions through knowledge of the role and functions of databases, different types of data storage, and the advantages and limitations of rigorous database systems in conjunction with statistical tools; and
- Describe the different types of database management systems, the ways these systems can provide data for analysis and interact with statistical software, and methods for evaluating technologies pertinent to both.

Teaching

- Review and illustrate selected principles of study design, probability theory, estimation, hypothesis testing, and data analytic techniques to public health students enrolled in first and second level graduate public health courses; and
- Explain advanced concepts in the theory of statistical inference to graduate students in biostatistics and mathematical statistics.

Biostatistical Research

- Identify and integrate new developments in the statistical literature for challenging research problems in public health; and
- Generate original computer code for new statistical techniques; and
- Recognize gaps in current inferential methods that limit further public health research and propose solutions based on rigorous theoretical justification.

Doctor of Public Health

Director: Roger D. Vaughan, DrPH

The Doctor of Public Health degree in Biostatistics (DrPH) prepares candidates to apply modern statistical methods to the solution of important public health problems as leaders of multidisciplinary research teams. The degree program is administered by the Standing Doctoral Committee of the Mailman School of Public Health, which carries out faculty policy on admission to the doctoral program and upholds the criteria for granting the degree.

Course Requirements

The Doctor of Public Health degree calls for completion of an approved program of study totaling no less than 30 doctoral credits. Upon completion of 30 credits of coursework, a student is permitted to take the written qualifying examination. In some instances it may be determined by the Department that a student needs more than 30 post-MPH course credits before the qualifying examination.

DrPH students must maintain continuous registration every semester from the start of the program until deposit of the doctoral dissertation. After completion of all coursework students register for Doctoral Research Registration (RSRHP0001) each term until they are ready to graduate.

Not more than 10 credits may be tutorials, and not more than six may be earned at the Master's level (e.g., 6000-level courses at the Mailman School of Public Health or 4000-level courses at the Graduate School of Arts and Sciences); the Department may apply to the Standing Doctoral Committee for a variance on the six-credit rule on a case-by-case basis.

A list of required courses is given below. Candidates for the DrPH degree are required to take the five core curriculum courses in public health (if they have not already done so during their MPH). Students wishing to waive one or more courses must request approval in writing from their advisors and the Director of Academic Programs.

A grade of B or better is necessary in all required courses. Up to 2 elective courses may be taken pass/fail.

Consulting Experience

The consulting experience is designed to enable students to demonstrate their ability to integrate their academic studies with the role of biostatistical consultant/collaborator, which will comprise a major portion of their future professional practice. P9185 Doctoral Consulting Seminar is a one-credit course offered each semester where students gain exposure to real world design, analysis, and report writing by helping CUMC investigators who come through the Biostatistical Consulting Service for design, data management, and statistical assistance. DrPH students are required to enroll in the Doctoral Consulting Seminar for at least one semester after obtaining 15 credits of course work.

Curriculum (TOTAL POINTS: 30 OR MORE)

Required Courses		Points
P6104	Introduction to Biostatistical Methods *(Summer, Fall)*	3
P8104	Probability *(Fall)*	3
P8108	Survival Analysis *(Fall)*	3
P8109	Statistical Inference *(Spring)*	3
P8111	Linear Regression Models *(Spring)*	3
P8116	Design of Medical Experiments *(Spring)*	3
P8120	Analysis of Categorical Data *(Fall, Spring)*	3
P8121	Generalized Linear Models *(Fall)*	3
P8140	Introduction to Randomized Clinical Trials *(Spring)*	3
P8157	Analysis of Longitudinal Data *(Fall)*	3
P9185	Doctoral Consulting Seminar *(Fall, Spring)*	0-1

Elective Courses		Points
P8114	Statistical Issues in Microarray Data	1
P8142	Clinical Trial Methodology	3
P8150	Seminar in Topics in Applied Statistics	3
P8158	Latent Variable and Structural Equation Modeling for Health Sciences	3
P8160	Topics in Advanced Statistical Computing	3
P8180	Research Data Coordination: Principles and Practices	3
P9113	Concepts of Modeling, Design, and Evaluation of Computer Experiments	3
P9120	Topics in Statistical Learning and Data Mining I	3
89260	Building Interdisciplinary Research Models	2

Departmental Colloquium

All doctoral students are required to attend the Departmental Colloquium and Research Talks held weekly each semester. Dates, times, and locations will be posted on the Doctoral bulletin board, as well as on the Department's website and Facebook page.

Qualifying Examination

There is a two-part qualifying examination for all DrPH candidates in Biostatistics that must be completed before going on to the oral comprehensive examination.

Part I - Basic Inference. The first part comprises a basic familiarity with statistical inference as presented in the course P8109 Statistical Inference. Students who have taken this course and have received a grade of B+ or above automatically satisfy the Part I requirement. Those students who do not receive this grade will be required to take a written examination testing their knowledge of the material in this course. This examination will be offered in the fall; alternatively, the student may sit for the final examination offered each spring for P8109. The examination given in the fall, if requested, will be similar to final examinations offered in P8109. It is the Department's expectation that most students will satisfy the Part I requirement by achieving a grade of B+ or above in P8109. In all cases, students must fulfill the requirement within two years of starting the doctoral program. Students must pass the Part I requirement before they may sit for the Part II exam.

Part II - Applications. The Statistical Applications Exam covers the practical analysis of data. The examination focuses on applied problems requiring statistical inference based on data analysis, with particular emphasis on material from P8108, P8111, P8116, P8120, and P8121. The skills required for this examination are generally furnished in the courses required for the MS degree. The purpose of the Statistical Applications Exam is to ensure that the student is able to determine the appropriate statistical and analytic approaches needed to solve real world public health / medical problems, correctly interpret the statistical results from these approaches, and translate and summarize those findings into language that public health and medical professionals would find useful. The Statistical Applications Exam is administered in a take-home format over a two-day period. While students are encouraged to use personal laptops and any familiar software, the computers in the Biostatistics Computer Lab are also available. The Statistical Applications Examination is typically given once a year, in the beginning of June.

Course Work and Progressing toward the Statistical Applications Exam. Preparation should include additional coursework in skills classes, review and thorough understanding of the material in the suggested readings, group and individual study sessions, completion of timed practice tests, and continuous enrollment in P9185 Doctoral Consulting Seminar. With approval and consent of his or her academic advisor, the student should inform the Director of Academic Programs two months in advance of sitting for the Statistical Applications Exam.

A score below 65% on Part II would generally be considered unsatisfactory. The student will be allowed no more than two attempts at passing either (Part I or Part II) examination. The Statistical Applications Exam must be taken and passed by the end of the third year in the DrPH program.

Questions from prior years are available to the student to assist in preparing for the examination.

Reading List

The following list consists of textbooks that are used in the courses required for the DrPH degree, plus additional references which are generally at the appropriate level for the DrPH Qualifying Examinations. Those marked with an asterisk are highly recommended to students preparing for their examinations.

Breslow NE and Day NE, *Statistical Methods in Cancer Research*

Conover WJ, *Practical Nonparametric Statistics*

Cox DR and Oakes D, *Analysis of Survival Data*

Fleiss JL, *The Design and Analysis of Clinical Experiments*

* **Fleiss JL, Levin B, and Paik MC**, *Statistical Methods for Rates and Proportions*

Hogg RV and Craig AT, *Introduction to Mathematical Statistics*

* **Hosmer D and Lemeshow S**, *Applied Logistic Regression*

* **Johnson RA and Wichern DW**, *Applied Multivariate Statistical Analysis*

Kalbfleisch JD and Prentice RL, *Statistical Analysis of Failure Time Data*

Kleinbaum DG and Kupper LL, *Applied Regression Analysis and other Multivariable Methods*

* **Lawless JF**, *Statistical Models and Methods for Lifetime Data*

* **Lee ET**, *Statistical Methods for Survival Data Analysis*

Lehmann ER, *Nonparametrics: Statistical Methods Based on Ranks*

Mardia KV, Kent JT, and Bibby JM, *Multivariate Analysis*

* **Mood AM, Graybill FA, and Boes D**, *Introduction to Statistical Inference*

Morrison DF, *Multivariate Statistical Methods*

* **Mosteller F and Tukey JW**, *Data Analysis and Regression*

* **Neter J, Wasserman W, and Kutner MH**, *Applied Linear Statistical Models*

Rao CR, *Linear Statistical Inference and Its Applications*

Scheffe H, *The Analysis of Variance*

Searle SR, *Linear Models*

Snedecor GW and Cochran WG, *Statistical Methods*

Tukey JW, *Exploratory Data Analysis*

Oral Comprehensive Examination

After completing all course work and passing the qualifying examination described above, the DrPH candidate begins planning for dissertation research. The oral comprehensive examination for the DrPH in Biostatistics is intended to examine the student's mastery of the current state of knowledge about his or her likely area of research, and thus to indicate whether the student is prepared to undertake such a project.

Composition of the Examining Committee. The examining committee will consist of five members approved by the chair of the Doctoral Program Subcommittee on Biostatistics, and will include:

i) three members who are inside examiners (i.e. holding a formal appointment or approved as a disseration sponsor);

ii) preferably two (but at least one) members who are outside examiners.

The latter faculty should represent disciplines closely related to the area of application of the student's proposed research. **After the sponsor obtains consent from each member, the *faculty sponsor* submits the list of names to the Chair of the Department and to the Chair of the Departmental Subcommittee on Biostatistics (DPSOB) for approval**, who then recommends the student's committee to the DrPH Committee of the Mailman School of Public Health.

Scheduling the Exam. The oral comprehensive examination should be taken within one year of passing the qualifying examination.

Nature of the Examination. After the committee selection and approval process has been completed, the student submits in writing a description of the current state of knowledge about the proposed area of research. This submission should be from 15 to 25 pages in length and contain between 15 and 20 references. This paper serves as the basis for the oral comprehensive examination. The student must give each member of the Examining Committee this written submission and discuss with each any additions or deletions that the committee member feels should be incorporated in the write-up. Since the final written submission and the references therein will constitute the basic material upon which the student will be examined, each member of the committee and the student must come to an agreement on the scope of the submission. It should be neither too narrow nor too broad in scope. After all members of the ad hoc committee approve the submission, the examination is scheduled within the next 60 days. The written submission may contain original results by the student, but this is not required.

ORAL COMPREHENSIVE EXAMINATION CONTINUED

Format of the Exam. The actual examination shall be an Oral Comprehensive Examination conducted by the Examining Committee as follows:

1. The chairman of the Examining Committee will not be the dissertation advisor but some other member of the ad hoc committee.
2. The examination will run approximately two hours and will consist of an oral presentation of the content of the written submission by the student (a planned presentation of about 30 minutes is appropriate), which may be interrupted by members of the Examining Committee with appropriate questions on the material presented or relevant related material. The chairman of the Examining Committee may challenge any question felt to be unrelated to the written submission and its background material.
3. After the presentation and questions, each member may ask additional questions of the examinee. Any such questions should be within the broad content of the written submission and its references. Again, the Examining Committee chairman may challenge any question felt to be too far removed from the basic material upon which the examination is based, namely on the written submission and the references therein.
4. After all questions are completed, the examinee leaves the room and the committee then votes on whether or not the examinee passed the examination. All members must agree in order for the student to pass the examination. Instead of pass or fail, the committee may unanimously decide upon the option of retesting the student within a six-month period on the same written submission.

The committee's decision will be put into writing by the chairman of the Examining Committee, as well as brief comments on the strengths and weaknesses of the student's performance as deemed necessary. Copies of this statement will be sent to the student and placed in the student's file.

Second Attempt at Passing. The student is entitled to no more than two attempts at passing the Oral Comprehensive Examination. The second attempt need not be based on the same written submission nor be examined by the same committee, but the same rules will govern the second attempt, including approval by the committee of the written submission. The second attempt must be made no more than 6 months after the first attempt.

Upon passing the Oral Comprehensive Examination, a student will typically ask his sponsor or another member of the faculty to agree to serve as the student's dissertation advisor and sponsor. No formal approval of a dissertation topic is required; however, a suitable and mutually agreeable topic must be established by the student and advisor. As stated earlier, it is often the case that the Oral Comprehensive Examination is on a topic that will become the student's dissertation topic, although this is not a formal requirement.

Progressing toward the Dissertation Defense

Between the Oral Exam and the Dissertation Defense, the DrPH student is required to present his/her research in a two public settings. The first is the Doctoral Research Seminar, usually held in the spring, where doctoral students at various stages of their research present a brief outline of their work to the faculty and their peers. The second setting is the preparation and presentation of a paper (or poster) at one or more of a number of professional societies. A select, but not exhaustive, list of such societies is presented below with their web links. More information is available on the Doctoral Bulletin Board. Travel funds are often available.

Example of Professional Society's / Associations:

- *International Biometric Society (ENAR/IBS)*
- *American Statistical Association (ASA)*
- *American Public Health Association (APHA)*
- *Society for Clinical Trials*

The Dissertation

Once a DrPH student has advanced to doctoral candidacy, s/he begins to develop a proposal for the dissertation project. The dissertation topic must deal with an important problem or issue in public health which can be addressed by the sound and original application of existing statistical methods. It must demonstrate that the candidate has engaged in independent and original research that has advanced our understanding of or knowledge about the public health problem, though the methods themselves need not be original. After the dissertation is successfully defended, the doctoral degree is awarded by the Mailman School of Public Health in the Faculty of Medicine.

In most cases, completion of DrPH course work and written qualifiers should take no more than two full-time academic years. On average, the dissertation may take an additional two or three full-time academic years. An overall time limit of seven years is set from the date of first registration as a doctoral student.

In unusual instances a student may wish to change dissertation sponsors, for instance, if the student's research leads to different areas of expertise than originally anticipated. In such cases the student may seek approval from a new faculty sponsor. The candidate must inform the Department Chair and the previous sponsor that the new sponsor will assume the previous sponsor's duties. At this point the student may also decide to pursue a new dissertation topic, with approval of the new sponsor, but in all cases the rules governing time limits and extensions remain in force.

DrPH candidates are required to submit a hard-bound copy of their funal dissertation to the department. Copies of past dissertations are available in the department administrative office (Room 626).

For more details regarding the DrPH disseration, the student is referred to the Mailman Student Handbook: **www.mailman.columbia.edu/people/current-students/academics/student-handbooks**.

Some Past DrPH Dissertation Titles

The titles below are provided to give students some idea of dissertation topics which in past years have proved appropriate for the DrPH degree:

Prognostic Modeling in the Presence of Competing Risks: An Application to Cardiovascular and Cancer Mortality in Breast Cancer Survivors, Nicole Leoce (2016)

New Estimating Equation Approach for the Secondary Trait Analyses in Genetic Case-Control Studies, Xiaoyu Song (2015)

Identifying Patterns in Behavioral Public Health Data Using Mixture Modeling with an Informative Number of Repeated Measures, Gary Yu (2013)

A Life Expectancy-based Comprehensive Quantification of Structural-level Health Disparities, Emma Benn (2012)

An Index of Aging-Relatedness with Relevance to Genetic and Environmental Contributions to Mortality and Disease Incidence in a Population, Gilberto Levy (2011)

The Familial Aggregation of Epilepsy, Anna Peljto (2010)

Analysis of the MT CT-Plus Initiative: An Application of a Piecewise Multilevel Latent Variable Regression Model, Shean-Sheng Wang (2010)

Analyses on Double-Blinded Fetal Tissue Transplant Study on Patients with Severe Parkinson's Disease and Reliability Assessment on Outcome Measurements, Richard Kao (2010)

Stepwise Procedures for Dose Finding in an Adaptive Clinical Trial of Early Rehabilitation After Acute Stroke, Xi Wu (2010)

Instrumental Variable Estimation for Survival Data: Evaluating the Effectiveness of Radiation Therapy for the Treatment of Lung Cancer in the Elderly in the Presence of Allocation Bias, Juan P. Wisnivesky (2009)

Doctor of Philosophy

Director: Ian McKeague, PhD

The Doctor of Philosophy in Biostatistics (PhD) prepares candidates for leadership roles in the development and application of statistical methods to biomedical research for the advancement of public health. The PhD is awarded by the Graduate School of Arts and Sciences (GSAS) as governed by the Doctoral Program Subcommittee on Biostatistics. The program is administered by the faculty and staff of the Mailman School of Public Health.

Course Requirements

Students take courses in the department of biostatistics, statistics, and other academic units representing various fields of application and/or related background material. A student should plan his or her course work in consultation with his/her academic advisor and/or the PhD subcommittee chair. Students wishing to waive one or more required courses must request approval in writing from their academic advisor and the Director of Academic Programs.

A grade of B or better is necessary in all required courses, except for P9111 which needs a B+ or better. Electives may be taken pass/fail, especially to encourage candidates to take courses outside his or her field of experience.

Statistical Inference Problem Seminar

To prepare for the Statistical Inference Qualifying Exam, students are required to take the problem seminar where students work on problems and discuss problem solving strategy useful for theory exam. The problem seminar is held throughout the first academic year (two semesters and the following summer).

Curriculum Practice Training

Students are strongly encouraged to work collaboratively with researchers or to take internship opportunities as they become available during their senior years in residence as curriculum practice training.

PhD Residence Requirements

All PhD students are required to accumulate six residence units (6 semesters of full-time study). After one year of study, students may apply for advanced standing of up to two residence units representing work completed in their Master's program. All PhD students are expected to attend full time, especially during the research and dissertation phases of their program. In instances of extreme financial hardship, students may be permitted to work part time during course work when tuition costs are higher.

Consulting Experience

The consulting experience is designed to enable students to demonstrate their ability to integrate their academic studies with the role of biostatistical consultant/collaborator, which will comprise a major portion of their future professional practice. P9185 Doctoral Consulting Seminar is a one-credit course offered each semester where students gain exposure to real world design, analysis, and report writing by helping CUMC investigators who come through the Biostatistical Consulting Service for design, data management, and statistical assistance. PhD students are required to enroll in the Doctoral Consulting Seminar during the fall and spring semesters of their second year.

Curriculum

Required Courses		Points
P6104	Introduction to Biostatistical Methods	3
P8104	Probability	3
P8108	Survival Analysis	3
P8109	Statistical Inference	3
P8111	Linear Regression Models	3
P8116	Design of Medical Experiments	3
P8120	Analysis of Categorical Data	3
P8121	Generalized Linear Models	3
P8140	Introduction to Randomized Clinical Trials	3
P8157	Analysis of Longitudinal Data	3
P8160	Topics in Advanced Statistical Computing	3
P9109	Theory of Statistical Inference I	4.5
P9110	Theory of Statistical Inference II	4.5
P9111	Advanced Topics in Statistical Inference	3
P9120	Topics in Statistical Learning and Data Mining I	3
P9185	Doctoral Consulting Seminar	0-1
GR6301	Probability Theory I	4

Elective Courses		Points
P8114	Statistical Issues in Microarray Data	1
P9133	Sequential Experimentation	3
P8142	Clinical Trial Methodology	3
P8144	Pharmaceutical Statistics	3
P8150	Seminar in Topics in Applied Statistics	3
P9154	Discrete Statistical Analysis	3
G4005	Introduction to Mathematical Genetics	3
G6101	Statistical Modeling for Data Analysis I	4
G6102	Statistical Modeling for Data Analysis II	4
G6103	Statistical Modeling for Data Analysis III	3
G6106	Probability Theory II	4.5

Departmental Colloquium

All doctoral students are required to attend the Departmental Colloquium and Research Talks held weekly each semester. Dates, times, and locations will be posted on the Doctoral bulletin board, as well as on the Department's website and Facebook page.

Qualifying Examination

There is a two-part qualifying examination for all PhD candidates in Biostatistics that must be completed before going on to the oral comprehensive examination.

Part I - Theory. The Statistical Inference (or Theory) Exam draws from material presented in the following courses: P9109, P9110, P8108, P8111, P8116, P8120, and P8121. The purpose of the Statistical Inference Exam, is to ensure that the PhD student is able to fully understand and use the mathematical and theoretical tools that form the basis of doctoral level biostatistical research. The Inference Exam requires solutions to five questions. The Statistical Inference Examination is typically given once a year, in the beginning of September.

Course Work and Progressing toward the Statistical Inference Exam. The incoming PhD student arrives after a summer working through real analysis problem sets and takes a placement test to ensure adequate understanding of the material. The first two semesters of the PhD program are typically devoted to adequate preparation for the Inference Exam which is typically taken in September of the student's second year in the program. Preparation should include coursework or mastery of content of the material in the required courses, review and thorough understanding of the material in the suggested readings, group and individual study sessions, and completion of timed practice tests. With approval and consent of the student's academic advisor, the student should inform the Director of Academic Programs two months in advance of sitting for the Statistical Inference Exam. Students must pass the Inference Exam before they may sit for the Applications Exam.

Part II - Applications. The Statistical Applications Exam covers the practical analysis of data. The examination focuses on applied problems requiring statistical inference based on data analysis, with particular emphasis on material from P8108, P8111, P8116, P8120, and P8121. The skills required for this examination are generally furnished in the courses required for the MS degree. The purpose of the Statistical Applications Exam is to ensure that the student is able to determine the appropriate statistical and analytic approaches needed to solve real world public health / medical problems, correctly interpret the statistical results from these approaches, and translate and summarize those findings into language that public health and medical professionals would find useful. The Statistical Applications Exam is administered in a take-home format over a two-day period. While students are encouraged to use personal laptops and any familiar software, the computers in the Biostatistics Computer Lab are also available. The Statistical Applications Examination is typically given once a year, in the beginning of June.

Course Work and Progressing toward the Statistical Applications Exam. Preparation should include additional coursework in skills classes, review and thorough understanding of the material in the suggested readings, group and individual study sessions, completion of timed practice tests, and continuous enrollment in the Doctoral Consulting Seminar. The Doctoral Consulting Seminar is a one-credit course offered each semester where students gain exposure to real world design, analysis, and report writing by helping CUMC investigators who come through the Biostatistical Consulting Service for design, data management, and statistical assistance. With approval and consent of his or her academic advisor, the student should inform the Director of Academic Programs two months in advance of sitting for the Statistical Applications Exam.

QUALIFYING EXAMINATION CONTINUED

A score below 65% on either Part I or Part II would generally be considered unsatisfactory. The student will be allowed no more than two attempts at passing either (Part I or Part II) exam. It is strongly recommended that the second attempt be made at the time of the next exam offering (usually 6 – 12 months later).

Questions from prior years are available to the student to assist in preparing for the examination.

Reading List

The following list consists of textbooks that are generally appropriate to use for preparing for the PhD qualifying examination.

Agresti A, *Categorical Data Analysis*

Bickel PJ and Doksum KA, *Mathematical Statistics*

Casella G and Berger RL, *Statistical Inference*

Cox D and Hinkley DV, *Theoretical Statistics*

Efron B and Tibshirani R, *An Introduction to the Bootstrap*

Fleiss JL, Levin B, and Paik MC, *Statistical Methods for Rates and Proportions*

Hastie T, Tibshirani R, and Friedman J, *The Elements of Statistical Learning*

Hettmansperger TP and McKean JW, *Robust Nonparametric Methods*

Hollander M, *Nonparametric Statistical Methods*

Johnson RA and Wichern DW, *Applied Multivariate Statistical Analysis*

Klein JP and Moeschberger ML, *Survival Analysis*

Lehmann EL, *Nonparametrics: Statistical Methods Based on Ranks*

Lehmann EL, *Point Estimation*

Lehmann EL, *Testing Statistical Hypotheses*

Lehmann EL, *Elements of Large-Sample Theory*

Lindgren BW, *Statistical Theory*

McCullagh P and Nelder JA, *Generalized Linear Models*

Morrison DF, *Multivariate Statistical Methods*

Rao CR, *Linear Statistical Inference and Its Applications*

Resnick S, *A Probability Path*

Robert CP and Casella, G, *Monte Carlo Statistical Methods*

Ruppert D, Wand MP, and Carroll R, *Semiparametric Regression*

Serfling RJ, *Approximation Theorems of Mathematical Statistics*

Shao J, *Mathematical Statistics*

Skrondal A and Rabe-Hesketh S, *Generalized Latent Variable Modeling*

van der Vaart A, *Asymptotic Statistics*

Oral Comprehensive Examination

After completing all course work and passing the two-part qualifying examination described in the previous sections, the PhD candidate begins planning for dissertation research and preparing for the Oral Exam. The Oral Comprehensive Examination is intended to demonstrate the student's mastery of the material in a defined statistical content area by verbally presenting a thorough description of the state of the art in that area, identifying limitations or areas of incomplete knowledge in that area, and proposing the development of new methods that would advance that area. This topic area may or may not end up being the student's dissertation topic. **The Oral Comprehensive Examination should be taken no later than the end of the Spring semester in the second year of study.** *Fellows in the program, please note, all tuition expenses incurred as a result of any delay in scheduling this exam shall be the responsibility of the student and not the Department of Biostatistics.*

Composition of the Examining Committee. The examining committee will consist of five members approved by the chair of the Doctoral Program Subcommittee on Biostatistics, and will include:

i) three members who are inside examiners (i.e. holding a formal appointment or approved as a disseration sponsor);

ii) preferably two (but at least one) members who are outside examiners.

The chair of the Examining Committee is to be a member of the Doctoral Program Subcommittee On Biostatistics. One member of this committee should be the faculty member who acts as the student's sponsor and anticipated thesis advisor. **With the consent of the members of the proposed committee, the *faculty sponsor* then submits their names for approval by the Chairman of the Doctoral Program Subcommittee on Biostatistics.**

Nature of the Examination. After the committee selection and approval process has been completed, the student submits in writing a description of the current state of knowledge about the proposed area of research. This submission should be from 15 to 25 pages in length and contain between 15 and 20 references. This paper serves as the basis for the oral comprehensive examination. The student must give each member of the committee this written submission and discuss with each any additions or deletions that the committee member feels should be incorporated in the write-up. Since the final written submission and the references therein will constitute the basic material upon which the student will be examined, each member of the committee and the student must come to an agreement on the scope of the submission and references. After such modifications to the written submission have been approved by all four members of the Examining Committee, the Comprehensive Exam is scheduled within the next 30 days. The written submission may contain original research by the student, but need not be original in content. It should not be too narrow in scope and should reflect the necessary basic material relevant to the student's chosen area of research. Before and during the examination, the three faculty examiners other than the student's sponsor make suggestions for and may insist on changes in the student's perception of the topic. Part of the student's written submission is an enumeration of as yet unanswered questions. The examiners make their opinions plain as to how important and challenging they perceive these questions to be.

ORAL COMPREHENSIVE EXAMINATION CONTINUED

Format of the Exam. The actual examination shall be an Oral Comprehensive Examination conducted by the Examining Committee as follows:

1. The chairman of the Examining Committee will not be the dissertation advisor but some other member of the ad hoc committee.
2. The examination will run approximately two hours and will consist of an oral presentation of the content of the written submission by the student (a planned presentation of about 30 minutes is appropriate), which may be interrupted by members of the Examining Committee with appropriate questions on the material presented or related material. The chairman of the Examining Committee may overrule any question felt to be unfair or unrelated to the written submission and its background material.
3. After the presentation and questions, each member may ask additional questions of the examinee. Such questions should be within the broad scope of the written submission and references. Again, the Examining Committee chairman may rule against any questions felt to be too far removed from the basic material upon which the examination is based, that is, the written submission and the references therein.
4. After all questions are completed, the examinee leaves the room and the committee then votes on whether or not the examinee passed the exam. Three of the four members must vote to pass the student in order for the student to pass the exam.

The committee's decision will be put into writing by the chairman of the Examining Committee, as well as brief comments on the strengths and weaknesses of the student's performance as deemed necessary. Copies of this statement will be sent to the student and placed in the student's file.

Second Attempt at Passing. The student is entitled to no more than two attempts at passing the Oral Comprehensive Examination. The second attempt need not be based on the same written submission nor be examined by the same committee, but the same rules will govern the second attempt, including approval by the committee of the written submission. The second attempt must be made no more than 6 months after the first attempt.

The examination and written submission are designed to focus the examination on basic material which is important to the student's area of research, and allow the Examining Committee to judge that the student fully comprehends this material. Upon passing the Comprehensive Examination, a student will typically ask his sponsor or another member of the PhD subcommittee to serve as the student's dissertation advisor and sponsor. No formal approval of a dissertation topic is required; however, a suitable and mutually agreeable topic must be established by the student and advisor. While it is usually the case that the Oral Comprehensive Examination is on a topic that will become the student's dissertation topic, this is not a formal requirement.

Advancement of PhD Students to the Master of Philosophy Degree

Upon the student's passing the qualifying and oral comprehensive examinations and the successful completion of four residence units beyond the Master's degree, he or she is awarded the Master of Philosophy degree. Failure of the Oral Comprehensive Examination implies that it is the Subcommittee's judgment the student is not yet prepared to carry out original research. The awarding of the Master of Philosophy to a student, on the other hand, certifies that the student has mastered the fundamental material necessary for him or her to conduct research in biostatistics. Students who apply for and receive two residence units of advanced standing are still required to complete four additional residence units before the Master of Philosophy may be awarded.

Progressing toward the Dissertation Defense

Between the Oral Exam and the Dissertation Defense, the PhD student is required to present his/her research in a two public settings. The first is the Doctoral Research Seminar, usually held in the spring, where doctoral students at various stages of their research present a brief outline of their work to the faculty and their peers. The second setting is the preparation and presentation of a paper (or poster) at one or more of a number of professional societies. A select, but not exhaustive, list of such societies is presented below with their web links. More information is available on the Doctoral Bulletin Board. Travel funds are often available.

Example of Professional Society's / Associations:

- *International Biometric Society (ENAR/IBS)*
- *American Statistical Association (ASA)*
- *American Public Health Association (APHA)*
- *Society for Clinical Trials*

Dissertation

The PhD dissertation is expected to contain original results of a mathematical and statistical nature in the solution of a problem in statistical theory or method which has relevance to a biomedical application. As a rule, the content of the dissertation should be adequate for publication in peer-refereed journals in the topic area of the dissertation. Students begin work on their dissertation research with the approval of their thesis sponsor and comprehensive examination committee. The only time limitation is the Graduate School of Arts and Sciences maximum of seven years from the time of enrollment in the doctoral program (the maximum is six years for those receiving advanced standing). Candidates who are making satisfactory progress toward finishing the dissertation have, upon application, been granted extensions by the Dean of GSAS, with the approval of their sponsor. With proper advising, PhD students should be able to finish the degree within five years of entry into the PhD program.

PhD candidates are required to submit a hardbound copy of their final dissertation to the department. Copies of past dissertations are available in the department administrative office (Room 626).

DISSERTATION CONTINUED

In unusual instances a student may wish to change dissertation sponsors, for instance, if the student's research leads to different areas of expertise than originally anticipated. In such cases, the student may seek approval from a new faculty sponsor. The candidate must inform the Doctoral Program Subcommittee Chair and the previous sponsor that the new sponsor will assume the previous sponsor's duties. At this point, the student may also decide to pursue a new dissertation topic, with approval of the new sponsor, but in all cases the rules governing time limits and extensions still apply. Upon completion of the dissertation, and with approval of the candidate's dissertation committee, the dissertation defense is scheduled.

For more details regarding the PhD dissertation, the student is referred to the Dissertation Office website: **www.gsas.columbia.edu/dissertations**. The GSAS Dissertation Office is located on the Columbia Morningside Heights campus at 107 Low Memorial Library, 535 W. 116th Street, New York, NY 10027. Information is also available in the Department of Biostatistics and the Dean's Office of GSAS on Morningside Campus.

Some Past PhD Dissertation Titles

The titles below are provided to give students some idea of topics that in past years have proved appropriate for the PhD degree:

Statistical Learning Methods for Personalized Medical Decision Making, Ying Liu (2016)

Survival Analysis using Bivariate Archimedean Copulas, Krishnendu Chandra (2015)

Learning Logic Rules for Disease Classification: With an Application to Developing Criteria Sets for the Diagnostic and Statistical Manual of Mental Disorders, Christine Mauro (2015)

Empirical likelihood tests for stochastic ordering based on censored and biased data, Hsin-wen Chang (2015)

Sequential Designs for Individualized Dosing in Phase I Cancer Clinical Trials, Xuezhou Mao (2015)

Methods for Handling Measurement Error and Sources of Variation in Functional Data Models, Xiaochen Cai (2015)

Statistical modeling and statistical learning for disease clarification and prediction, Tianle Chen (2014)

Sequential Quantile Estimation Using Continuous Outcomes with Applications in Dose Finding, Chih-Chi Hu (2014)

Two-stage continual reassessment method and patient heterogeneity for dose-finding studies, Xiaoyu Jia (2014)

Wavelet-based Procedures for Scalar-on-function Regression, Adam Ciarleglio (2013)

Sample Size Calculations for the Semiparametric Analysis of Short-term and Long-term Hazard Ratios, Yi Wang (2013)

On Composition Data Modeling and Its Biomedical Applications, Bingzhi Zhang (2013)

Flexible Models and Methods for Longitudinal and Multilevel Functional Data, Huaihou Chen (2012)

Sparse Functional Regression Models: Minimax Rates and Contamination, Wei Xiong (2012)

Regression Based Principal Component Analysis for Sparse Functional Data with Applications to Screening Pubertal Growth Paths, Wenfei Zhang (2012)

Sparse Selection in Cox Models with Functional Predictors, Yulei Zhang (2011)

On Testing the Change-Point in the Longitudinal Bent Line Quantile Regression Model, Nanshi Sha (2011)

The Limb-leaf design: A New Way to Explore the Dose Response Curve in Adaptive Seamless Phase II/III Trials, John Spivack (2011)

Multiple Testing Procedures to Identify the Therapeutic Window in Phase I/II Clinical Trials, Rui Liu (2011)

Power Under Local Alternatives for Generalized Estimating Equations with Applications to Sibling Studies, Zhigang Li (2010)

Wavelet-Based Functional Linear Regression, Yihong Zhao (2010)

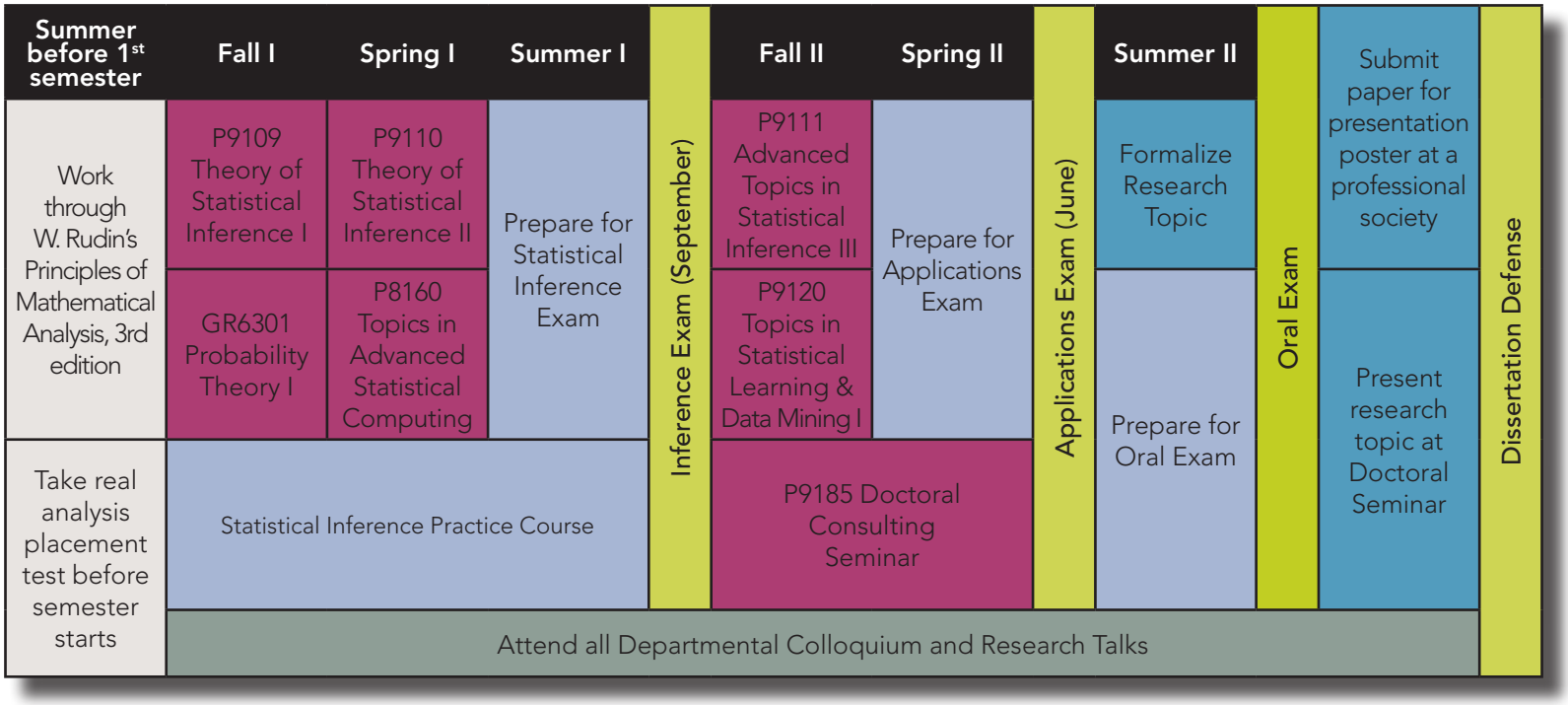
Model Selection Based on Quadratic Distances-An Alternative to AIC, Rositsa Dimova (2010)

Practical Implementation of the Continual Reassessment Method for Dose Finding Cancer Trials, Shing Lee (2009)

Sequential Test for Right Censored Data with Linear Transformation Model, Lin Huang (2009)

Regularized Estimation of Covariance Matrices for Longitudinal Data Through Smoothing and Shrinkage, Wanling Tai (2009)

Typical PhD Timeline



Department of Biostatistics Courses

These are the courses offered by the Department of Biostatistics. Due to faculty commitments, the frequency of the courses changes from time to time. Students are advised to check the current schedule of courses listed on the MSPH web page: **www.mailman.columbia.edu/academics/courses**. Students may also review the course offerings of the Statistics Department at the Morningside Campus in the Graduate School of Arts and Sciences: **www.stat.columbia.edu**.

Students are encouraged to meet with their faculty advisors at least twice a year – in the fall and in the spring. Permission is not required for approved courses in a student's approved program of study. Students must first obtain permission from their faculty advisors to take courses outside the approved program. **Failure to comply with these guidelines may jeopardize plans for graduation.**

P6103 Introduction to Biostatistics 3 points

Prerequisites: Permission of the instructor required for all non-Public Health students.

Biostatistics is essential to ensuring that findings and practices in public health and biomedicine are supported by reliable evidence. This course covers the basic tools for the collection, analysis, and presentation of data in all areas of public health. Central to these skills is assessing the impact of chance and variability on the interpretation of research findings and subsequent recommendations for public health practice and policy. Topics covered include: general principles of study design; hypothesis testing; review of methods for comparison of discrete and continuous data including ANOVA, t-test, correlation, and regression.

P6104 Introduction to Biostatistical Methods 3 points

Prerequisites: Placement exam required, and the instructor's permission.

An enriched core course for students concentrating in biostatistics and others who expect to take additional courses in biostatistics beyond the two main second-level courses (P8100 and P8120). It covers in greater depth all of the topics in P6103 and is the best preparation for students anticipating a quantitative orientation in their degree programs. Topics covered include standard distributions, measures of central tendency and dispersion, hypothesis testing, point estimation, confidence intervals, and an introduction to correlation and regression.

P6107 Biostatistical Analysis Using SPSS 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and the instructor's permission.

A logical follow-up course to an introductory biostatistics course. Covers uses of the computer in cleaning, summarizing, and cross-classifying data. Enhancement of the material covered in P6103/ P6104— including regression, correlation, and contingency table analysis, and the analysis of variance– with data analysis carried out using SAS software.

P6110 Statistical Computing with SAS 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and the instructor's permission.

A logical follow-up course to an introductory biostatistics course. Covers uses of the computer in cleaning, summarizing, and cross-classifying data. Enhancement of the material covered in P6103/ P6104— including regression, correlation, and contingency table analysis, and the analysis of variance– with data analysis carried out using SAS software.

P6120 Introduction to Statistical Genetics 3 points

Prerequisites: No prior statistical genetics experience is required, although familiarity with basic statistical concepts and methods will be helpful.

The course will offer students the opportunity to gain fundamental skills for the analysis of genetic data from human studies. Course's students will acquire a theoretical and practical training in statistical genetic research, becoming familiar and proficient in the different statistical methods, strategies and available resources that will facilitate their careers as successful investigators.

P6170 New Drug Development: A Regulatory Overview 3 points

Prerequisite: P6103 or P6104, and P6400.

Provides our CTSA fellows and scholars with insights into and understanding of the process of patient oriented/translational research and gives them an opportunity to meet active investigators from academia and industry, and learn about some career enhancing resources available at CUMC. Active researchers from various clinical disciplines and public health are invited to speak on research techniques, design, and laboratory methodology as applied to current studies. They present their experiences in conducting patient orientated research on the Health Sciences campus and elsewhere. Also features speakers from both the pharmaceutical and biotech industries who discuss drug development, and preclinical and clinical trials. Other lectures deal with FDA regulations, patent law, and the Institutional Review Board and ways to effectively build and succeed in a clinical/translational academic career.

P8100 Applied Regression I 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and the instructor's permission.

Attention: This course is not an approved elective for the MS/TM, MS/APT, or the MPH programs.

The study of linear statistical models. Regression and correlation with one independent variable. Partial and multiple correlation. Multiple and polynomial regression. Single factor analysis of variance. Simple logistic regression. Note: this course is not an approved elective for the MS/TM, MS/APT, or MPH program.

P8102 Basic Laboratory Methods: Tools for Translational Research 1 point

Prerequisites: Instructor's permission.

Attention: This is a required course for all MS-POR students.

This course serves to introduce students to many of the widely used laboratory research methods which could be employed to support clinical research. These methods include imaging (fMRI), molecular genetics, cell culture methods, use of animal models, high-throughput genetic and functional screening approaches, various methods for protein- and DNA-based analysis, as well as applications to cancer, metabolic and genetic disorders. Students will present a brief project proposal employing selected methods covered in the course.

P8103 Colloquium on Patient Oriented Research 2 points (0.5 points x 4 semesters)

Prerequisite: This is a required course for MS-POR students, CTSA K12 scholars, and CTSA T32 trainees. Permission required.

Provides our CTSA fellows and scholars with insights into and understanding of the process of patient oriented/translational research and gives them an opportunity to meet active investigators from academia and industry, and learn about some career enhancing resources available at CUMC. Active researchers from various clinical disciplines and public health are invited to speak on research techniques, design, and laboratory methodology as applied to current studies. They present their experiences in conducting patient orientated research on the Health Sciences campus and elsewhere. Also features speakers from both the pharmaceutical and biotech industries who discuss drug development, and preclinical and clinical trials. Other lectures deal with FDA regulations, patent law, and the Institutional Review Board and ways to effectively build and succeed in a clinical/translational academic career.

P8104 Probability 3 points

Prerequisites: P6104 (may be corequisite), working knowledge of calculus, and the instructor's permission.

Topics include: Fundamentals, random variables, and distribution functions in one or more dimensions; moments, conditional probabilities, and densities; Laplace transforms and characteristic functions. Infinite sequences of random variables, weak and strong large numbers; central limit theorem.

P8108 Survival Analysis 3 points

Prerequisites: P8104, P8109, P8111, and the instructor's permission.

Topics include: Clinical trials concerning chronic disease, comparison of survivorship functions, parametric and non-parametric models for patterns of mortality and other kinds of failures, and competing risks.

P8109 Statistical Inference 3 points

Prerequisites: P8104, working knowledge of calculus and linear algebra, and the instructor's permission.

Topics include: Population parameters. Sufficient statistics. Basic distribution theory. Point and interval estimation. Method of maximum likelihood. Method of least squares regression. Introduction to the theory of hypothesis testing. Likelihood ratio tests. Nonparametric procedures. Statistical design theory.

P8110 Applied Regression II 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, P8100, and the instructor's permission.

An introduction to the application of statistical methods in survival analysis, generalized linear models, and design of experiments. Topics to be covered include estimation and comparison of survival curves, regression models for survival data, log-linear models, logit models, analysis of repeated measurements, and the analysis of data from blocked and split-plot experiments. Examples are drawn from the health sciences.

P8111 Linear Regression Models 3 points

Prerequisites: P8104, P8109 (may be corequisite), some computer background, working knowledge of calculus and linear algebra, and the instructor's permission.

Topics include: The theoretical background underlying regression techniques. Simple regression. Bivariate normal distribution and correlation. Multiple and polynomial regression.

P8112 Systematic Review and Meta-Analysis 1.5 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and P6400 .

Research synthesis using systematic review and meta-analysis is one of the most valuable of research endeavors, and can be a particularly rewarding experience for junior investigators who want to develop expertise in a specific area of public health or medicine by producing a product with significant scientific impact. This course will combine lecture and workshop elements to introduce students to the principles and practices of systematic review and meta-analysis. It will be targeted to students who have previously been introduced to the concepts of basic biostatistics, epidemiology, and clinical trials. By the end of the course, each student (as part of a group) will have conducted a systematic review and meta-analysis of a topic chosen by their group. The emphasis in this course is on the actual conduct of systematic review and meta-analysis, so morning lectures are followed daily by afternoon lab/workshop hours during which instructors support students in mastering each stage of the research process. As a culminating experience, students make oral presentations summarizing the process they followed, unexpected challenges, main findings, and plans for future research using their newly acquired research synthesis skills.

P8114 Statistical Issues in Microarray Data: Workshop and Journal Club 1 point

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, a basic biology course, and the instructor's permission.

Attention: This course must be taken Pass/Fail.

Microarrays are devices used to simultaneously measure features of tens of thousands of genes. In a journal club format, this course exposes students to the new field of high-throughput genomic data as well as its analytical challenges. Students are required to either present their own relevant research project or data analysis, or lead a discussion on a topical journal article. Students who complete this course are able to list scientific problems where microarray experiments are useful; recognize fundamental statistical and design issues arising in the analysis of microarray data; assess the methodological strengths and weaknesses of studies analyzing microarray data published in peer-reviewed biomedical journals; and identify appropriate statistical tools to apply to microarray data addressing basic research questions.

P8116 Design of Medical Experiments 3 points

Prerequisites: P8104, P8109, P8111, and the instructor's permission.

Topics include: Principles in the design and analysis of controlled experiments: Latin squares, incomplete block designs, crossover designs, fractional factorial designs, confounding.

P8119 Advanced Statistical and Computational Methods in Genetics and Genomics 3 points

Prerequisites: P6104 and the instructor's permission.

This course introduces students to advanced computational and statistical methods used in the design and analysis of high-dimensional genetic data, an area of critical importance in the current era of Big Data. The course starts with a brief background in genetics, followed by in depth discussion of topics in genome-wide linkage and association studies, and next-generation sequencing studies. Additional topics such as network genetics will also be covered. Examples from recent and ongoing applications to complex traits will be used to illustrate methods and concepts.

P8120 Analysis of Categorical Data 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, P6400 (may be corequisite), and the instructor's permission.

A comprehensive overview of methods of analysis for binary and other discrete response data, with applications to epidemiological and clinical studies. Topics discussed include the fourfold table, significance versus magnitude of association; estimation of relative risk; matching in design and analysis; interrater agreement; logistic regression analysis.

P8121 Generalized Linear Models 3 points

Prerequisites: P8104, P8109, P8111, and the instructor's permission.

Begins with an examination of generalization of the classical linear regression models. Specific topics followed include models for binary response data such as probit and logit models, analysis of data with discrete ordered responses, models for count data, log-linear models for contingency tables, and analysis of continuous data where the variability increases with the mean. In each topic, description of data analysis methods comes with example of application.

P8133 Adaptive Designs for Clinical Trials 3 points

Prerequisites: P8104 and P8109 or their equivalents, and the instructor's permission.

An introduction to sequential analysis as it applies to statistical problems in clinical trials, hypothesis testing, selection, and estimation. Emphasis is placed on a study of procedures, operating characteristics, and problems of implementation, rather than mathematical theory. Students obtain an overview of currently available sequential designs and the advantages and disadvantages they offer in comparison with classical designs.

P8134 Stochastic Approximation and Modern Dose-Finding 3 points

Prerequisites: P8104 and P8109 or their equivalents, and the instructor's permission.

Provides an in-depth study of statistical designs for dose-finding clinical trials of new drugs. This course is designed for advanced Master's, DrPH, and PhD students in biostatistics. The overall learning objective is to equip students with the techniques to construct, evaluate, and critique dose-finding designs. The course consists of two parts. The first is a review of modern dose-finding techniques with a focus on the continual reassessment method (CRM) and its clinical applications. The second part presents advanced topics on stochastic approximation and its related theory. Connections between the dose-finding methods (part 1) and the stochastic approximation (part 2) will be drawn. The practical implication of these connections is two-fold. First, the stochastic approximation will provide a versatile and mathematically rigorous framework for tailoring dose-finding designs to specific clinical situations. Second, the well-studied theory of stochastic approximation will be an effective analytical tool to approximate the theoretical properties of the CRM.

P8139 Statistical Genetics Modeling 3 points

Prerequisites: P6103 or P6104, a working knowledge of calculus, and the instructor's permission.

Present to students statistical tools so that they can grasp the fundamentals of the design, conduct and analysis of genetic association studies. The course will thoroughly discuss current methods that are being used to map genes for common complex diseases. Great emphasis will be placed on candidate-gene and genome-wide association studies, but linkage methods will also be treated. Another key feature of this course will be a detailed treatment of the major findings of the Human Genome Project and HapMap Project.

P8140 Introduction to Randomized Clinical Trials 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and the instructor's permission.

Fundamental methods and concepts of the randomized clinical trial: protocol development, randomization, blindedness, patient recruitment, informed consent, compliance, sample size determination, crossovers, collaborative trials. Each student prepares and submits the protocol for a real or hypothetical clinical trial.

P8142 Clinical Trial Methodology 3 points

Prerequisites: P6103 or P6104, and the instructor's permission.

The main objective of this course is to provide students and investigators with a working knowledge of certain methodological issues that arise in designing a clinical trial in order to conduct complex study designs that yield valid and reliable results. With emphasis on several methodological and practical issues related to the design and analysis of clinical experiments, topics include: the design of small studies (Phase I and II studies), interim analyses and group sequential methods, survival studies, multiple outcome measures, surrogate outcomes, multicenter studies, issues in data analysis, and reporting and interpreting study results.

P8144 Pharmaceutical Statistics 3 points

Prerequisites: P6103 or P6104, and the instructor's permission. P8120 and P8110 or P8111 are recommended.

Drug development from compound discovery to marketing and commercialization registration is a lengthy and complex process in which statisticians play an important role from beginning to end. The main objective of this course is to provide students with working knowledge of the methodological and operational issues that arise in different stages of drug development that involve statistical contributions. Topics include: Introduction of drug development; design and analysis of toxicology studies, pharmacokinetics and pharmacodynamics studies, biomarker studies, Phase I/II/III studies; issues in clinical studies such as non-inferiority studies, meta-analysis, and endpoint selection; and preparation for the FDA advisory committee drug approval process. In addition, the views and positions of different regulatory bodies, such as the FDA or EMEA, on design and analysis will be discussed.

P8149 Statistical Population Genetics 3 points

Prerequisites: P8104 and the instructor's permission.

This course will cover all statistical aspects of population genetics. Upon completion of this course, the students will be able to model and do inference of underlying population genetic mechanisms and apply acquired knowledge about population genetics to the analyses of phenotypes.

P8150 Seminar in Topics in Applied Statistics 3 points

Prerequisites: P8104, P8109, P8111, and the instructor's permission.

Presentation of recently developed ideas in applied statistics, which may include: the EM algorithm; the jackknife, bootstrap, and other resampling methods; model selection; regression diagnostics, and wavelet approach to analyzing fMRI brain imaging data.

P8157 Analysis of Longitudinal Data 3 points

Prerequisites: P8104, P8109, P8111, and the instructor's permission.

Topics include features of repeated measurements studies: balance in time, time-varying covariates, and correlation structure. Examination of the models for continuous repeated measures based on normal theory: random effects models, mixed models, multivariate analysis of variance, growth curve models, and autoregressive models. Nonparametric approaches and models for repeated binary data. Applications of generalized linear models to repeated data. Empirical Bayes approaches are discussed as time allows.

P8158 Latent Variable and Structural Equation Modeling for Health Sciences 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and the instructor's permission.

This course is designed for those students (or any researchers) who want to gain a significant familiarity with a collection of statistical techniques that target the measurement of latent variables (i.e. variables that cannot be measured directly) as well as methods for estimating relationships among variables within causal systems. This course covers: both continuous and categorical latent variable measurement models (i.e. exploratory and confirmatory factor analysis, item response theory models, latent class and finite mixture models), as well as estimation of relationships in hypothesized causal systems using structural equation modeling. Data analysis examples will come from health science applications and practical implementation of all methods will be demonstrated using predominately the Mplus software, but also the R software.

P8160 Topics in Advanced Statistical Computing 3 points

Prerequisites: P8109, a basic understanding of Bayesian inference, working knowledge of a programming language, and the instructor's permission.

As statistical models become increasingly complex, it is often the case that exact or even asymptotic distributions of estimators and test statistics are intractable. With the continuing improvement of processor speed, computationally intensive methods have become invaluable tools for statisticians to use in practice. This course covers the basic modern statistical computing techniques and how they are applied in a variety of practical situations. Topics include numerical optimization, random number generation, simulation, Monte Carlo integration, permutation tests, jackknife and bootstrap procedures, Markov Chain Monte Carlo methods in Bayesian settings, and the EM algorithm.

P8163 Statistical Methods in Genetic Epidemiology Journal Club 0.5 points

Prerequisites: P6103 or P6104, P6400, P8175, and the instructor's permission.

The course will explore current literature in statistical methods for genetic epidemiology, providing opportunity and incentive for students, theoreticians, and practitioners to keep abreast of the rapidly growing issues of this field.

P8165 Statistical Genetics 1.5 points

Prerequisites: Invited scholars only (MS-POR, CTSA K12 and T32). Email csri@columbia.edu to inquire.

The course will offer students the opportunity to gain fundamental skills for the analysis of genetic data from human studies. Students will acquire a theoretical and practical training in statistical genetic research, becoming familiar and proficient in the different statistical methods, strategies and available resources that will facilitate their careers as successful investigators.

P8177 Biostatistics in Legal Proceedings 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, or another first course in biostatistics or statistics.

The course will examine the role that statistical evidence plays in legal proceedings such as toxic tort cases, class actions in the areas of equal employment opportunity and equal opportunity in housing, voting rights cases, patent disputes, challenged elections, adverse events in drug trials, calculation of damages resulting from theft, collusion, health insurance fraud, and other audits involving sampling, and many more, in settings ranging from jury trials, bench trials, administrative hearings, arbitration hearings, depositions, and the lawyer's office. In addition, studies of the legal system itself are proliferating and are increasingly statistical in nature, with entire journals devoted to the subject.

P8180 Research Data Coordination: Principles and Practices 3 points

Prerequisites: P6103 or P6104 or MPH Quantitative Foundations, Evidence, and Policy core course, and the instructor's permission.

Provides a conceptual framework for the management of data in modern health science research projects in which original data are collected from individual subjects. The course is structured to parallel the temporal sequence in a research project, beginning with data-related considerations in the preparation of a grant proposal, database design, reporting and data delivery systems, and ending with the preparation of reports and publications and the dissemination of research findings. Emphasis on institutional and regulatory issues, including the emergence of data coordinating centers and the implications of the Health Insurance Portability and Accountability Act (HIPAA).

P8182 Writing a Successful Grant Application 1 points

Prerequisites: Concurrent enrollment in the Columbia Summer Research Institute. Required for MS-POR students.

This seminar-style course will lead students through the process of writing an NIH-style grant application. By the end of the course, each student submits a research proposal outline following NIH guidelines for either an R01 or K (career development) award. The emphasis in this course is on the quality of the proposed research, taking into account feasibility, relevance, innovation, ethical foundation, and public health impact. As a culminating experience, students make oral presentations summarizing their research proposals to an invited panel of senior, experienced CUMC faculty, and receive feedback on their proposed research aims and approaches.

P8183 Writing an NIH Grant Proposal: INTENSIVE WORKSHOP 0.5 points

Prerequisites: By invitation and/or application only. Email csri@columbia.edu to inquire.

How do grants get funded? This intensive, workshop-style, one-day course will instruct students in the process of writing and submitting an NIH-style grant application. It will also focus on the grants review process, because understanding how to review a grant is the best way to understand how to write a grant. By the end of the course, each student writes and revises a specific aims page following NIH guidelines for an R01 award. The emphasis in this course is on the potential of proposed research aims, taking into account feasibility, relevance, innovation, ethical foundation, and public health impact. Students produce two versions of the aims page, and receive feedback from experienced faculty on their proposed research hypotheses and presentation of their research aims.

P8185 Capstone Consulting Seminar 1 point

Prerequisites: At least 15 points of required coursework in biostatistics, and the instructor's permission.

Required capstone course for the MS Theory and Methods track and MPH students in Biostatistics. Provides experience in the art of consulting and in the proper application of statistical techniques to public health and medical research problems. Enables students to translate research objectives into statistical hypotheses, devise appropriate study designs, perform sample size calculations for studies employing simple random sampling, formulate and prepare written plans for statistical analysis for a research proposal, compose summaries of quantitative analyses, and communicate results clearly to public health colleagues. Based on seminars requiring active student participation.

P9109 Theory of Statistical Inference I 4.5 points

Prerequisites: P8104, P8109, and the instructor's permission.

A rigorous introduction to mathematical statistics for doctoral students in biostatistics. Topics to be covered include: statistics, sufficiency, completeness, basics of point estimation, hypothesis testing, unbiased estimation, least squares estimation, maximum likelihood estimation, uniformly most powerful tests, the Neyman-Pearson lemma, and likelihood ratio testing.

P9110 Theory of Statistical Inference II 4.5 points

Prerequisites: P8104, P8109, P9109, and the instructor's permission. This is a continuation of P9109.

This course continues the introduction to mathematical statistics for doctoral students in biostatistics. Topics to be covered include: principles of decision theory, Bayesian estimation, Hypothesis testing, asymptotics, M-estimation, Wald tests, and score tests.

P9111 Advanced Topics in Statistical Inference 3 points

Prerequisites: P8104, P8109, P9109, P9110, and the instructor's permission.

The choice of topics will vary from year to year, but will typically include: empirical processes and M-estimation, bootstrap methods, empirical likelihood, contiguity, local asymptotic normality, counting process methods in survival analysis, semiparametric inference and efficiency.

P9120 Topics in Statistical Learning and Data Mining I 3 points

Prerequisites: Intended for Biostatistics PhD students in their second year or higher and theoretically inclined DrPH or MS students of Biostatistics.

Provide students a systematic training in key topics in modern supervised statistical learning and data mining. For the most part, the focus will remain on a theoretically sound understanding of the methods (learning algorithms) and their applications in complex data analysis, rather than proving technical theorems. Applications of the statistical learning and data mining tools in biomedical and health sciences will be highlighted.

P9154 Discrete Statistical Analysis 3 points

Prerequisites: P8104, P8109 P8120, and the instructor's permission.

Discrete univariate and multivariate distributions; sampling models for discrete data; maximum likelihood and best asymptotically normal estimation; asymptotic behavior of goodness of fit statistics; homogeneity of association and symmetry in multiway contingency tables; log-linear models; polytomous logistic regression.

P9160 Master's Essay in Biostatistics: Clinical Research Methods 3 points

Prerequisites: At least 15 points of required coursework, and the instructor's permission.
Attention: This course is for MS/CRM students only.

Students produce a Master's essay in the form of a research article of publishable quality, supervised by faculty members from Biostatistics and from the student's own clinical field.

P9161 Master's Essay in Biostatistics: Clinical Research Methods II 0.5-3 points

Attention: This course is for MS/CRM students who will take courses in a summer-intensive format through CSRI.

Students produce a Master's essay in the form of a research article of publishable quality, supervised by faculty members from Biostatistics and from the student's own clinical field. In addition, students will also produce a NIH-style grant application for submission after completing all coursework.

P9165 Master's Essay in Biostatistics: Patient Oriented Research 0 points

Prerequisites: At least 15 points of required coursework, and the instructor's permission.
Attention: This course is for MS-POR students only.

Students produce a Master's essay in the form of an NIH-style grant application, supervised by a project sponsor from Biostatistics and a mentor from the student's own clinical field. A formal presentation to the POR advisory board is required for successful completion of the course.

P9185 Doctoral Consulting Seminar 0-1 point

Prerequisites: At least 15 points of required coursework, and the instructor's permission.

Required course for the DrPH and PhD students in biostatistics. Provides experience in the art of consulting and in the proper application of statistical techniques to public health and medical research problems. Enables students to translate research objectives into statistical hypotheses, devise appropriate study designs, perform sample size calculations for studies employing simple random sampling, formulate and prepare written plans for statistical analysis for a research proposal, compose summaries of quantitative analyses, and communicate results clearly to public health colleagues. Based on seminars requiring active student participation.

P6190, P8190, P9190 Tutorials in Biostatistics 1 to 6 points

For appropriately qualified students wishing to enrich their programs by undertaking literature reviews, special studies, or small group instruction in topics not covered in formal courses. Hours to be arranged.

89260 Building Interdisciplinary Research Models 2 points

Interdisciplinary research is an approach to advancing scientific knowledge requiring mastery of specific competencies. This seminar will introduce the students to competencies in interdisciplinary research through a combination of readings and lectures in each necessary aspect, chosen from fields essential to successful interdisciplinary research. This course will assist learners to understand why and how different professional disciplines, each representing a body of scientific knowledge, must work together to generate and disseminate knowledge. Learners will develop a set of skills specific to be an effective member and leader of an interdisciplinary research team, and will become familiar with the advantages of team science.

Colloquia

During the Fall and Spring semesters, the Department of Biostatistics holds seminars on a wide variety of topics which are of interest to both students and faculty. The speakers are occasionally departmental faculty members themselves but very often are invited guests who spend the day of their seminar discussing their research with Biostatistics faculty and students. While all students are strongly urged to attend, **doctoral student attendance is mandatory.**

Consulting Service

All MS/PS, MS/SG, MS/TM and doctoral students are required to participate in the Biostatistics Consulting Service. This program is designed to enable students to demonstrate their ability to integrate academic studies with the role of biostatistical consultant/collaborator. The Biostatistics Consulting Service offers advice on data analysis and appropriate methods of data presentation for publications, and provides design recommendations for public health and clinical research, including preparation of grant proposals.

Participation in the Biostatistics Consulting Service meets the MS/PS, MS/SG, and MS/TM capstone requirement while providing students with an opportunity to gain invaluable experience working with a diverse clientele on a variety of statistical problems.

Teaching Assistantships

Each semester, the Department makes available a limited number of Teaching Assistant (TA) positions. Upon completion of one full semester of course work, eligible students may apply for a TA slot. Students are advised to carefully consult the following policy on qualification, selection, and compensation of TAs before considering one of these positions. All TA candidates must apply to the Assistant Director of Academic Programs.

To qualify for a TA position, students must:

- NOT be employed by another department at Columbia University
- have successfully completed the course of interest
- maintain a GPA of 3.3 or better
- be able to devote up to 15 hours per week to TA duties. This includes, but is not limited to:
    - 3 hours spent in class for lectures
    - up to 2 hours in recitation periods (for core teaching assistants)
    - 1-2 regularly scheduled office hours
    - 4-8 hours per week for homework grading and preparation of teaching materials

Selection of TAs is made by the instructor and Assistant Director of Academic Programs. Priority is given to students in doctoral programs, students with greater seniority, and students with previous TA experience who have received good evaluations from their former students and course instructors.

TA compensation is taxable and is paid out over the course of the semester.

The Practicum Requirement

The intent of the practicum requirement is to engage students in activities aligned with their career goals, as well as activities that demonstrate application of biostatistical methods and public health concepts relevant to the student's area of interest. Students will seek out activities that further develop their skill set and add new tools to their professional toolkit. Upon completion of the practicum, the student will be able to provide evidence of application of these skills to potential employers. Practicum placements are made on an individual basis in consultation with faculty advisors who must approve both the proposed practicum prior to its initiation. Students and mentors must complete an evaluation at the conclusion of the practicum experience.

Goals of the Practicum are:

For the Department of Biostatistics

• To provide the University with a part of the formative assessment of the student's ability to function as a Biostatistician; and

• To serve as a means of continually evaluating the relevance and effectiveness of the curriculum, leading to modifications of the formative and summative assessments when necessary.

For the Student

• To provide a continuing series of practical experiences geared to his or her level of expertise, which will offer a chance to apply principles, skills, and techniques that have been acquired;

• To help the student learn how to assume professional roles in a variety of practice settings while becoming accustomed to a range of organizational structures, working relationships, and job expectations; and

• To help the student develop professional identification as a Biostatistician and gain experience in fulfilling his or her role as a team member working with other professionals.

For the Mentoring Institution/Organization

• To provide mentorship input into the university program and, thereby, allow staff to share in the development of future Biostatisticians;

• To serve as a growth experience for the mentor's staff through interaction with the students; and

• To provide the mentor an opportunity to recruit employees and reduce the time needed for on-the-job training of any students who, upon graduation, are hired.

Practicum Roles

The ***student*** is responsible for identifying potential practicum sites and making arrangements for his or her practicum experience at an appropriate site. Appropriate sites will offer professional training and specialization. Sites must be approved by the student's faculty advisor. Ideally, the practicum placement should be approved **no less** than a month before the beginning of the practicum.

In addition to the student, there are three individuals with roles in the practicum experience; they are:

1. **Faculty Advisor**: the student's assigned advisor reviews and approves the proposed practicum as being relevant to the student's program track and career interests. The advisor must also endorse the student's suitability as well as his or her cognitive ability for a given practicum experience.

2. **Department Practicum Coordinator**: Corey Adams, 212-305-9399; (ca2594@cumc.columbia.edu). The Department Practicum Coordinator is responsible for supervision of the practicum experience once the advisor and mentor have approved the general concept and basic objectives for a given practicum.

3. **Practicum Mentor**: the field supervisor who provides the educational experience and mentorship, which are at the heart of the practicum experience. Practicum mentors should be motivated to host practicum experiences from a sense of professional commitment to help students achieve professional skills and status. For the purposes of the practicum, a qualified mentor may include database administrators, researchers, professors, doctors, etc. It is necessary, that a mentor fully operate effectively at a professional level in his/her field.

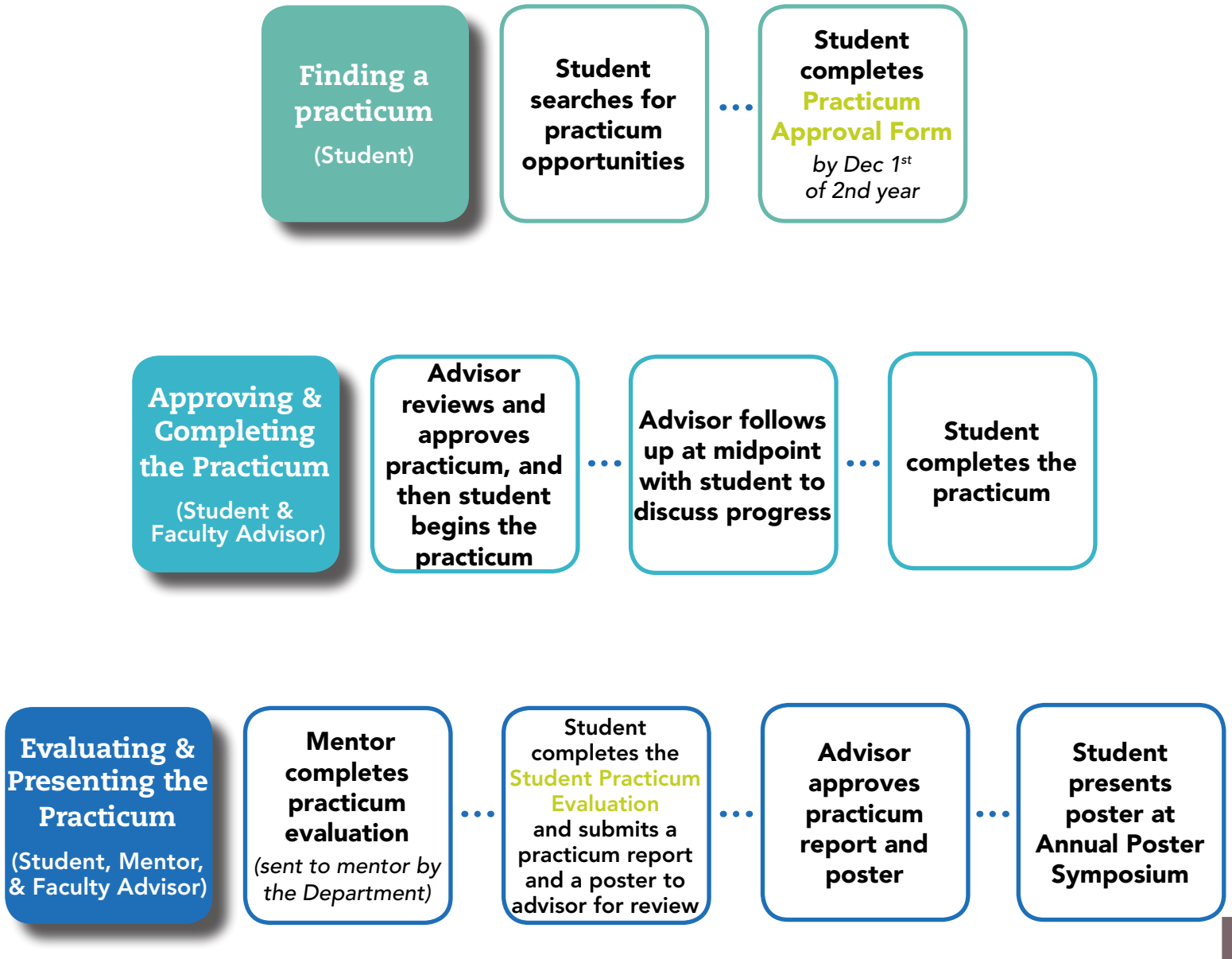
Student Requirements for Completing the Practicum Requirements

1. The student is reponsible for finding a practicum and for completing the online **Practicum Approval Form**, at least one month before the start of the practicum. The form should be submitted no later than December 1st of the student's second year.

2. Once approved, the student begins his or her practicum experience. Before completing the practicum, the student and his or her advisor should meet at the midpoint to discuss progress.

3. After the completion of the practicum, the student completes the online **Student Practicum Evaluation**, and submits a practicum report and a poster to his or her advisor for approval. The student will present his or her poster at the Annual Practicum Poster Symposium.

The Process of Completing the Practicum Requirement



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BIOSTATISTICS

2016-2017 STUDENT HANDBOOK

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