



THE GEORGE
WASHINGTON
UNIVERSITY
WASHINGTON DC

**Columbian College of Arts and Sciences
and
School of Public Health and Health Services**

**Ph.D. Biostatistics
2009-2010**

Note: All curriculum revisions will be updated immediately on the website <http://www.gwumc.edu/sphhs>

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The PhD degree program in Biostatistics is a 72 credit degree program jointly administered by the Department of Statistics in the Columbian College of Arts and Sciences (CCAS) and the Department of Epidemiology and Biostatistics in the School of Public Health and Health Services (SPHHS), and its associated research facility, The Biostatistics Center. This degree program is accredited by the Middle States Council on Higher Education through the CCAS and by the Council on Education for Public Health through the SPHHS. Regulations and requirements for this graduate degree have been designed to be compatible with policies and scholarship requirements of both the CCAS and SPHHS. The degree is conferred by the CCAS.

At the completion of the PhD degree program in Biostatistics students will be able to:

- Conduct biostatistical methodology research.
- Understand the theory and principles of probability, statistical inference, and biostatistical methods including contingency tables, survival analysis, mixed models, and missing data
- Apply appropriate biostatistical methods for design and analysis of biomedical studies.
- Provide biostatistical advice as a member of a team engaged in a biomedical research project

Admissions Requirements

Applicants must hold an undergraduate degree from an accredited institution of higher learning. Applicants should have academic backgrounds of excellence, usually with majors, or equivalent, in the fields in which they intend to study for advanced degrees. Normally, a B average (or equivalent) from an accredited college is required. With evidence of special promise, such as high Graduate Record Examination scores, an applicant whose academic record falls short of a B average may be accepted on a conditional basis. Meeting the minimum requirements does not assure acceptance. The departments may, and often do, set higher admission standards. Moreover, the number of spaces available for new graduate students limits the number who can be accepted. Students who apply in their senior year must provide evidence of the completion of their baccalaureate work before registration in Columbian College is permitted. Applicants should be aware that graduate courses taken prior to admission while in non-degree status are not used in assessing admissibility to degree programs and may not be transferable into those programs. The Program-at-a-Glance presents the Ph.D. curriculum for students admitted to the Ph.D. program with no intermediate Master's degree.

If desired, a student may complete the M.S. program prior to admission to the Ph.D. degree program, in which case no more than 24 credit hours from the M.S. degree may be applied to the Ph.D. course work requirements. In this instance the student will be required to take a minimum of 27 additional credit hours of coursework (including 3 credits of consulting). The distribution of these courses between statistics and public health would depend on the nature of the Master's degree and whether the transferred credit hours would be used to defray statistics or public health course work.

The consulting requirement may be waived by the Biostatistics Program Director based on a written documentation of prior equivalent course work or on the basis of relevant work experience. However, the waiver of all or part of this requirement does not alter the total number of credits required for the degree. Thus, waiver of these consulting courses will require equivalent credit hours of additional course work from among the list of electives.

Undergraduate Course Requirements (or equivalents to these GW courses) for Admissions Consideration:

MATH	031	Single-Variable Calculus I	3	Limits and continuity. Differentiation and integration of algebraic and trigonometric functions with applications.
MATH	032	Single-Variable Calculus II	3	The calculus of exponential and logarithmic functions. L'Hopital's rule. Techniques of integration. Infinite series and Taylor series. Polar coordinates. Prerequisite: Math 31
MATH	033	Multivariable Calculus	3	Partial derivatives and multiple integrals. Vector-valued functions. Topics in vector calculus, including line and surface integrals and the theorems of Gauss, Green, and Stokes. Prerequisite: Math 32
STAT	118	Regression Analysis	3	Lecture 3 credits, laboratory 1 hour. Simple and multiple linear regression, partial correlation, residual analysis, stepwise model building, multicollinearity, and diagnostic methods, indicator variables. Prerequisite: Introductory Statistics

Additional Course Requirements

Applicants lacking these courses (or equivalents to these GW courses) will be considered for admission, but, if admissible, will be admitted conditionally with the expectation that these courses will be satisfactorily completed within two semesters following matriculation in the program. These credits do not count as credit toward the 72 credit graduation requirement nor are grades earned in additional courses reflected in the overall grade point average.

Additional Course Requirements (or equivalents to these GW courses):

MATH	033	Multivariable Calculus III	3	Partial derivatives and multiple integrals. Vector-valued functions. Topics in vector calculus, including line and surface integrals and the theorems of Gauss, Green, and Stokes. Prerequisite: MATH 032
MATH	84	Linear Algebra I	3	Linear equations, matrices, inverses, and determinants. Vector spaces, rank, eigenvalues, and diagonalization. Applications to geometry and ordinary differential equations. Prerequisite: MATH 031
STAT or	129	Introduction to Computing	3 or	Introduction to personal and mainframe computers and their operating system, spreadsheets with simple statistical applications, and programming with applications to technology. Fall and Spring
STAT or	183	Intermediate Statistical Laboratory: Statistical Computing Packages	3 or	Application of program packages (e.g., SAS, SPSS) to the solution of one-, two- and k-sample parametric and nonparametric statistical problems. Basic concepts in data preparation, modification, analysis and interpretation of results. Prerequisite: an introductory statistics course. Fall and Spring
PubH	249	Use of Statistical Packages: Data Management and Data Analysis	3 cr	This course familiarizes the student with one of the most widely used database management systems and statistical analysis software packages, the SAS System, operating in a Windows environment. Throughout the course, several database management system techniques and data analytical strategies for the appropriate analysis of datasets obtained from a variety of studies will be presented. Statistical techniques covered include linear regression, analysis of variance, logistic regression, and survival analysis. Fall and Spring.

Full information is available in the online Graduate Admissions Application at www.gwu.edu/~gradinfo. A detailed description of admissions policies is also available online at www.gwu.edu/~ccas.

Ph.D. Biostatistics Degree Requirements

The Ph.D. will require a total of 72 credit hours of course work and research, with a minimum of 51 credits of courses and a minimum of 12 credits of dissertation research.

Course Distribution Summary	Credits
Core Courses <ul style="list-style-type: none"> Statistics (27 Credits) 	39

<ul style="list-style-type: none"> Public Health (12 Credits) 	
Approved Elective Courses <ul style="list-style-type: none"> Statistics (at least 3 credits) Public Health 	9
Consulting Note: May be waived by the Biostatistics Program Director, based on written documentation of prior equivalent course work or relevant work experience. Waiving all or part of this requirement does not alter the 72 total credit requirement. Waiver of the consulting course increases the total number of electives by the number of consulting credits waived.	3
Dissertation Research	12-24
Total Credits	72

The General and Final Examinations

The General Examination is given in two parts.

Part I, is a written comprehensive examination based on the course content of STAT 202 STAT 213 (administered by faculty of the Department of Statistics), and PUBH 266 (administered by the faculty of the Department of Epidemiology and Biostatistics). Students are expected to take the comprehensive examination within 24 months from the date of enrollment in the program. In addition, students are required to make up any deficiencies prior to taking the examination, e.g., by enrolling in appropriate master's-level courses as needed. A student who fails to pass the comprehensive examination may, with the approval of the faculty, repeat the examination the following year. Failure on the second attempt will result in termination from the Ph.D. program.

Part II, the research proposal, consists of an oral examination based on a written dissertation research proposal. As soon as feasible after successful completion of the comprehensive exam, students are encouraged to identify a dissertation advisor and a topic of research. The written dissertation proposal is then submitted to the student's Dissertation Research Committee, and the student will make an oral presentation of his or her proposal to the Committee. The Committee will determine the student's readiness to pursue and successfully complete the proposed research, in addition to the appropriateness of the specific problem for dissertation level research.

Upon successful completion of the required course work and both parts of the General Examination, the candidate will generally be recommended to the Associate Dean for Graduate Affairs of The Columbian College of Arts and Sciences (CCAS) for promotion to PhD **Candidacy**: the dissertation research. A candidate must file an approved dissertation research plan with the CCAS before being admitted to PhD Candidacy. Prior to completion of the General Examination, a student may register for at most 6 credit hours of Dissertation Research (BIOS 399).

The document [Doctoral Dissertation Reference Guide](#) describes the specific requirements for the doctoral dissertation established by the *Program Management Committee*.

Professional Enhancement Requirement (8 hours)

Professional enhancement activities supplement the academic curriculum and help prepare students to participate actively in the professional community. They enhance practical knowledge and awareness of public health issues – either in general or in a student's specific area of study.

Students can fulfill this requirement by attending workshops, seminars, or other relevant professional meetings, which are often held at SPHHS and in the metropolitan Washington, DC area. Examples of conference sponsors include the National Academy for State Health Policy, the Pan American Health Organization, the American Public Health Association, the American College of Healthcare Executives, the Area Health Education Center, the American College of Sports Medicine, and the National Athletic Trainer's Association. Opportunities for professional enhancement are regularly publicized via the SPHHS Listserv and through your department or advisor.

Students must submit documentation of Professional Enhancement activities to the Office of Student Records. The documentation consists of the Professional Enhancement Form (see www.gwumc.edu/sphhs/sacd/forms.htm), which includes a prior approval signature from the student's advisor, a description of the program agenda, and proof of attendance.

Remember to submit your documentation *before* you apply to graduate!

Please see the curriculum sheets that follow.



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Ph.D. Biostatistics

**Program-at-a-Glance
2009-2010**

Required Statistics Core Courses (27 Total Credits)

Required Statistics Core Courses (15 Credits)		Credits	Semester Offered	Grade
STAT 201	Mathematical Statistics I	3	Fall, Spring	
STAT 202	Mathematical Statistics II <i>Basis for PhD General Comprehensive</i>	3	Fall, Spring	
STAT 210	Data Analysis	3	Spring	
STAT 213	Intermediate Probability <i>Basis for PhD General Comprehensive</i>	3	Spring	
PubH 265	Design of Medical Studies	3	Spring	
PubH 266	Biostatistical Methods <i>Basis for PhD General Comprehensive</i>	3	Fall	
STAT 226	Advanced Biostatistical Methods	3	Spring	
STAT 227	Survival Analysis	3	Fall Alternate Years	
STAT 263	Advanced Statistical Theory I	3	Fall	

Required Public Health Core Courses (12 Credits)

PubH 201	Biological Concepts for Public Health	2	Summer, Fall, Spring	
PubH 203	Principles and Practice of Epidemiology	3	Fall, Spring	
PubH 221	Environmental and Occupational Epidemiology	3	Spring	
PubH 209	Topics May be repeated for credit	1	Summer, Fall, Spring	
	One of the following:			
PubH 205	Policy Approaches to Public Health	2	Summer, Fall, Spring	
PubH 207	Social and Behavioral Approaches to Public Health	2	Summer, Fall, Spring	
PubH 208	Management Approaches to Public Health	3	Fall, Spring	

Approved Elective Courses (9 Total Credits)

Approved Statistics Elective Courses (at least 3 credits)		Credits	Semester Offered	Grade
Recommended Statistics Electives				
STAT 231	Categorical Data Analysis	3	Fall, Alternate Years	
STAT 262	Nonparametric Inference	3	TBD	
Other Statistics Elective Courses				
STAT 207	Methods of Statistical Computing I	3	TBD	
STAT 208	Methods of Statistical Computing II	3	TBD	
STAT 215	Applied Multivariate Analysis I	3	Alternate years	
STAT 216	Applied Multivariate Analysis II	3	Alternate years	
STAT 217	Design of Experiments	3	Fall, alternate years	
STAT 218	Linear Models	3	Spring, alternate years	
STAT 223	Bayesian Statistics: Theory and Applications	3	Spring, alternate years	
STAT 242	Regression Graphics/Nonparametric Regression	3	Spring, alternate Years	
STAT 257	Probability	3	Fall	
STAT 258	Distribution Theory	3	Spring	
STAT 264	Advanced Statistical Theory II	3	Spring	
STAT 265	Multivariate Analysis	3	Fall, alternate years	
STAT 273	Stochastic Processes I	3	Alternate years	
STAT 274	Stochastic Processes II	3	Alternate years	

STAT 281	Advanced Time Series Analysis	3	Spring	
BIOS 398	Advanced Reading and Research	variable	See Advisor	
Approved Public Health Elective Courses		Credits	Semester Offered	Grade
Recommended Public Health Elective				
PubH 242	Clinical Epidemiology and Decision Analysis	3	Spring	
Other Public Health Elective Courses				
PubH 245	Infectious Disease Epidemiology	2	Spring	
PubH 246	Injury Epidemiology and Prevention	2	Fall	
PubH 403	Measurement in Public Health and Health Services Research	3	Spring	
Consulting (3 Credits)				
Note: May be waived by the Biostatistics Program Director, based on written documentation of prior equivalent course work or relevant work experience. Waiver of the consulting course increases the total number of electives by the number of consulting credits waived.				
PubH 209.58	Consulting Practicum	2	Summer, Fall, Spring	
PubH 258	Advanced Topics in Biostatistical Consulting	1	Spring	
Dissertation Research (12-24 Credits)				
BIOS 399	Dissertation Research for PhD Biostatistics Students	1-12	Summer, Fall, Spring	



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Statistics Course Descriptions

STAT	201-2	Mathematical Statistics I-II	3-3	Probability, distribution theory, sampling theory, estimation, sufficient statistics, hypothesis testing, analysis of variance, multivariate normal distribution. Prerequisite: MATH 33, 84. Fall, Spring
STAT	207	Methods of Statistical Computing I	3	Error analysis, computational aspects of linear models, sweep operator, random number generation, simulation and resampling. Optimization, numerical integration (Gaussian quadrature, Simpson's rule); EM algorithm. Prerequisite: STAT 118, 157-8; MATH 84; knowledge of a computer programming language.
STAT	208	Methods of Statistical Computing II	3	Numerical linear algebra, matrix decomposition and eigenvalue problems. Smoothing and density estimation. Graphics, interactive and dynamic techniques for data display. Object-oriented programming. Prerequisite: STAT 118, 157-58; MATH 124; and knowledge of a programming language.
STAT	210	Data Analysis	3	Review of statistical principles of data analysis, using computerized statistical procedures. Multiple regression and the general linear model, analysis of contingency tables and categorical data, logistic regression for qualitative responses. Prerequisite: STAT 118, either Stat 183 or demonstrated proficiency in computer programming, and one semester of mathematical statistics (STAT 157 or STAT 201). Spring
STAT	213	Intermediate Probability and Stochastic Processes	3	Discrete and continuous random variables and their distributions, conditional distributions and conditional expectation, generating functions and their applications, convergence of random variables; and introduction to the Brownian motion, homogeneous and nonhomogeneous Poisson processes and martingales. Prerequisite: STAT 201 and STAT 202. Spring, alternate years
STAT	215	Applied Multivariate Analysis I	3	Application of multivariate statistical techniques to multidimensional research data from the behavioral, social, biological, medical and physical sciences. Prerequisite: STAT119, STAT157 and STAT158; MATH 84. Alternate academic years
STAT	216	Applied Multivariate Analysis II	2	Application of multivariate statistical techniques to multidimensional research data from the behavioral, social, biological, medical and physical sciences. Prerequisite: STAT119, STAT157 and STAT158; MATH 84. Alternate academic years
STAT	217	Design of Experiments	3	Design and analysis of the single- and multiple-factor experiments. Includes block designs, repeated measures, factorial and fractional factorial experiments, response surface experimentation. Prerequisite: STAT 119, STAT 157 and STAT 58; MATH 84. Fall
STAT	218	Linear Models	3	Theory of the general linear parametric model. Includes least squares estimation, multiple comparisons procedures, variance components estimation. Prerequisite: STAT 201 and STAT 202; MATH 84. Spring
STAT	223	Bayesian Statistics: Theory and Applications	3	An overview of Bayesian statistics, including its foundational issues, decision under uncertainty, linear models, expert opinion, and computational issues. Prerequisite: STAT 201 and STAT 202. Spring, alternate years

STAT	226	Advanced Biostatistical Methods	3	Statistical methods for the analysis of longitudinal data: nonparametric, fixed effects, mixed effects, generalized estimating equations. Methods for the analysis of emerging data: group sequential analysis, Brownian motion, Bayesian methods and stochastic curtailment. Other advanced topics of current research in biostatistics. Prerequisite: STAT 201-202 or permission of instructor. Spring
STAT	227	Survival Analysis	3	Parametric and nonparametric methods for the analysis of events observed in time (survival data), including Kaplan-Meier estimate of survival functions, logrank and generalized Wilcoxon tests, the Cox proportional hazards model and an introduction to counting processes. Prerequisite: Stat 201-2 or permission of instructor. Fall
STAT	231	Categorical Data Analysis	3	A study of the theoretical bases underlying the analysis of categorical data. Measures and tests of association; Mantel-Haenszel procedure; weighted least squares and maximum likelihood estimators in linear models; estimating equations; logistic regression; loglinear models. Prerequisite: STAT 201 and STAT 202. Fall, alternate years
STAT	242	Regression Graphics /Nonparametric Regression	3	Linear regression, nonparametric regression, smoothing techniques, additive models, regression trees, neural networks, and dimension reduction methods. Prerequisite: Stat 118; Math 33, 84, or equivalent. Spring, alternate years
PubH	265	Design of Medical Studies	3	Design of medical investigations, including the randomized clinical trial, observational cohort study, and the retrospective case-control study. Specific methods regarding sample size, power and precision and statistical procedures for randomization and sampling. Ethics of clinical trials and the intention-to-treat principle. Prerequisite: PubH 202, Spring
PubH	266	Biostatistical Methods <i>Basis for PhD General Comprehensive</i>	3	Biostatistical methods for asymptotically efficient tests and estimates of relative risks and odds ratios from prospective and retrospective matched and unmatched studies. Fixed and random effects models. Logistic regression, conditional logistic regression. Poisson regression. Maximum likelihood and efficient scores. Prerequisites: STAT 202 or Instructor's permission, Fall
STAT	257	Probability	3	Probabilistic foundations of statistics, probability distributions, random variables, moments, characteristic functions, modes of convergence, limit theorems, probability bounds. Prerequisite: Stat 201-2, knowledge of calculus through functions of several variables and series. Fall
STAT	258	Distribution Theory	3	Special distributions of statistics, small and large sample theory, order statistics, and spacings. Prerequisite: Stat 257. Spring
STAT	262	Nonparametric Inference	3	Inference when the form of the underlying distribution is unspecified. Prerequisite: STAT 201 and STAT 202.
STAT	263	Advanced Statistical Theory I	3	Decision theoretic estimation, classical point estimation, hypothesis testing. Prerequisite: STAT 201 and STAT 202. Fall
STAT	264	Advanced Statistical Theory II	3	Asymptotic theory, hypothesis testing, confidence regions. Prerequisite: Stat 257, 263. Spring
STAT	265	Multivariate Analysis	3	Multivariate normal distribution. Hotelling's T^2 and generalized T^{20} , Wishart distribution, discrimination and classification. Prerequisite: STAT 201 and STAT 202 and MATH 124. Fall alternate years
STAT	266	Topics in Multivariate Analysis	3	Multivariate analysis of variance, principal components, canonical correlation, factor analysis. Prerequisite: Stat 265.
STAT	273	Stochastic Processes I	3	Fundamental notions of Markov chains and processes, generating functions, recurrence, limit theorems, random walks, Poisson processes, birth and death processes, applications. Prerequisite: STAT 201-202. Alternate years

STAT	274	Stochastic Processes II	3	Fundamental notions of Markov chains and processes, generating functions, recurrence, limit theorems, random walks, Poisson processes, birth and death processes, applications. Prerequisite: STAT 201-202. Alternate years
STAT	281	Advanced Time Series Analysis	3	Autoregressive integrated moving average (ARIMA) modeling and forecasting of univariate and multivariate time series. Statespace or Kalman filter models, spectral analysis of multiple time series. Theory and applications using the University computer. Prerequisite: Math 33, Stat 201—2 or equivalent. (Spring)
BIOS	398	Advanced Reading and Research	variable	Limited to students preparing for the Doctor of Philosophy general examination. May be repeated for credit. See Advisor

Public Health Course Descriptions

PubH	201	Biological Concepts for Public Health	2	Provides an overview of current knowledge about biological mechanisms of major diseases causing death and disability in the US and globally; understanding and interpreting the reciprocal relationships of genetic, environmental, and behavioral determinants of health and disease in an ecologic context; analyzing, discussing, and communicating biologic principles of disease from a public health perspective. Summer 1, Fall, Spring
PubH	203	Principles and Practice of Epidemiology	3	General principles, methods, and applications of epidemiology. Outbreak investigations, measures of disease frequency, standardization of disease rates, study design, measures of association, hypothesis testing, bias, effect modification, causal inference, disease screening, and surveillance. Case studies apply these concepts to a variety of infectious, acute, and chronic health conditions affecting the population. Fall, Spring, Summer 10 week
PubH	205	Policy Approaches to Public Health	2	Introductory multidisciplinary course focusing on the interplay of all aspects of global public health on health policy problems. Students will learn how health policy is made, how health care and public health services are delivered, and how to define and analyze key health policy problems drawing on the perspectives and skills of the public health disciplines. Prerequisites: None. Summer, Fall, Spring
PubH	207	Social and Behavioral Approaches to Public Health	2	This course will emphasize social and behavioral science theories, models, and concepts that can be applied to public health problems and interventions. This course will describe the role of social and community factors, including race/ethnicity and culture, in both the onset and solution of public health problems and describe the inter-relationship between the social/behavioral science. Summer 1, Fall, Spring
PubH	208	Management Approaches to Public Health	3	An advanced multidisciplinary course examining global public health and health delivery issues through the use of a case study approach. Prerequisites: PubH 201.202.203.204.205.206 or 207. Summer, Fall, Spring
PubH	209	Topics	1 to 3	In-depth examination of a particular facet of public health. Topics and prerequisites vary. May be repeated for credit Summer, Fall, Spring
PubH	209.58	Consulting Practicum	1	In this course students gain experience in applying their biostatistical skills to assist in projects being conducted by Medical Center researchers. The course director assigns projects to students according to their background and provides individual supervision. Prerequisite: PubH 258. Summer, Fall, Spring
PubH	221	Environmental and Occupational	3	Epidemiologic methods for the study of environmental and occupational health problems. Epidemiologic exposure assessment methods and methods relevant to cohort, case-control, cross-sectional, and cluster

		Epidemiology		investigation studies. Sources of and evaluation of biases and confounding, as well as survey and questionnaire design. Prerequisites: PubH 203.202, Spring
PubH	245	Infectious Disease Epidemiology	2	The role and conduct of laboratory and field investigations in the epidemiology of infectious diseases. Prerequisite: PubH 203, Spring
PubH	246	Injury Epidemiology and Prevention	2	Epidemiologic knowledge and prevention strategies for intentional and unintentional injuries, including those occurring in transportation, occupational, home, and recreational environments. Research methods, sources of data, and application to injury prevention. Prerequisite: PubH 203, Fall
PubH	242	Clinical Epidemiology and Decision Analysis	2 + 1	Quantitative and qualitative approaches to decision making, including risk- benefit analysis, decision analysis, and cost-effective analysis. Applications to technology assessment; development of clinical guidelines. PubH 202.203, Spring Note: MPH and MS Health Policy and Doctoral Students concurrently take PubH 209 topics course by the same name for 1 credit.
PubH	258	Advanced Topics in Biostatistical Consulting	1	Principles and practice of biostatistical consulting in public health and medical research environments. Spring
PubH	403	Measurement in Public Health and Health Services Research	3	Reviews principles of measurement and assessment as they apply to public health and health services research constructs, reviews existing state-of –the-art measures of individual and population health status (e.g., morbidity, mortality, functioning and health-related quality of life) and of individual and community health behavior, and explores current measurement issues in health research. Prerequisite: PubH 260, Spring
BIOS	399	Dissertation Research	1 to 12	Dissertation Research for PhD EPI Students