

Biostatistics

Many issues in the health, medical, and biological sciences are addressed by collecting and exploring relevant data. The development and application of techniques to better understand such data is the fundamental concern of the Group in Biostatistics. The program offers training in theory of statistics and biostatistics, the computer implementation of analytic methods, and opportunities to use this knowledge in areas of biological/medical research. The curriculum is taught principally by members of the Division of Biostatistics (School of Public Health) and the Department of Statistics (College of Letters & Science) and provides a wide range of ideas and approaches to the analysis of data.

Established in 1955, the Graduate Group in Biostatistics curriculum offers instruction in statistical theory and computing, as well as opportunities to rigorously apply this knowledge in biological and medical research. The degree programs offered (listed below) are appropriate for students who have either a strong mathematical and statistical background with a focus in the biomedical sciences, or degrees in the biological sciences with a focus in mathematics and statistics. (The MA degree can be obtained under Plan I or Plan II. The PhD dissertation is administered according to Plan B.)

Master of Arts (MA)

The Masters of Arts Degree in Biostatistics is completed in 4 semesters. Candidates for this degree are expected to earn 48 units with courses in biostatistics, statistics, public health, and biology. The 12-unit minimum enrollment requirement per semester may be met with independent research or seminar courses. Students must enroll for all four semesters of the program. Students pursuing the MA degree in Biostatistics will be expected, upon completion of the program, to be well-versed in the following areas:

- Fundamental statistical methods, including statistical estimation, hypothesis testing, regression analysis, analysis of variance, and longitudinal data.
- Algorithms and computer applications.
- Analysis of multivariate data—categorical and continuous—with particular emphasis on epidemiology.
- Interpretation of survival analysis data and issues, including knowledge of life table methodology, competing causes of death, medical follow-up studies, parametric models, and nonparametric methods.
- Computational biology methods including gene mapping, microarray data analysis, and other topics in genomics.
- Methods of analysis using vital and health statistics, census data, rates, and adjusted rates.

Master of Arts/Doctor of Philosophy (MA/PhD)

The Biostatistics MA/PhD degree track was recently created for those students who ultimately want to earn the Biostatistics PhD but do not already hold a masters degree (only in rare circumstances are applicants coming from the baccalaureate program admitted straight into the PhD program). After completion of the MA portion of the degree program, it is straightforward admission to the PhD degree track. This does not prolong the time to the doctorate since the coursework completed in the first two years is the same for the Biostatistics MA and PhD degrees.

Doctor of Philosophy (PhD)

All Biostatistics PhD students are required to hold a master's degree in Biostatistics or a related field. The PhD degree requires 4-6 semesters of course work in biostatistics, statistics, and at least one other subject area (e.g., biology, environmental health, epidemiology). There are no unit or course requirements for the PhD, so a program of courses appropriate to a student's background and interests may be developed. Courses cover traditional topics as well as recent advances in biostatistics and in statistics. Those completing the PhD will have acquired a deep knowledge and understanding of these subject areas. Since graduates with doctorates often assume academic careers in research and teaching, a high degree of mastery in research design, theory, methodology, and execution is expected as well as the ability to communicate and present research findings and area of expertise in a clear, understandable manner.

Biostatistics doctoral graduates have gone on to teaching careers at colleges and universities, both here in the US and internationally. Others have pursued careers as biostatisticians in the pharmaceutical/biotech industries, health care delivery organizations, medical schools and schools of public health across the US and abroad. The demand for biostatisticians with advanced training is high, particularly for those seeking teaching and research careers.

Biostatistics Doctor of Philosophy (PhD) with Designated Emphasis (DE)

Students enrolled in the UC Berkeley Biostatistics doctoral (PhD) program are eligible to apply for interdisciplinary study in a Designated Emphasis (DE), which we refer to as the Associated Programs. At UC Berkeley, acquiring a DE is like earning a "minor" with a PhD degree. Applications for Designated Emphasis are reviewed on a rolling basis throughout the year; however students must apply prior to taking the qualifying exam and are strongly encouraged to begin the application process early in the third semester of graduate study. To be accepted to a Designated Emphasis, you must be a PhD candidate in one of the Associated Programs (e.g., Biostatistics). The two DE programs offered in biostatistics are:

- Designated Emphasis in Computational and Genomic Biology (DE-CGB) (<http://qb3.berkeley.edu/ccb>)
- Designated Emphasis in Computational Science and Engineering (DE-CSE) (<http://cse.berkeley.edu>)

The goal of the DE-CGB program is to train a new generation of computational biology researchers by enhancing and facilitating interactions between faculty, postdoctoral scholars and students in the Associated Programs through a flexible and integrated research and teaching environment which transcends traditional departmental boundaries. Upon successful completion of all requirements and dissertation, your transcript and diploma will read, "PhD in Biostatistics with a Designated Emphasis in Computational & Genomic Biology."

The DE in Computational Science and Engineering (CSE) promises to bring a new paradigm to interdisciplinary research and education. The team-oriented approach provides our students with a solid foundation in the different facets of genomic research and ensuing competitive edge for the most desirable jobs in academia and industry, which increasingly require interdisciplinary training by combining high-performance computing, mathematical modeling, scientific and engineering theory, and analysis of large scale data bases of observations. Upon successful completion of all requirements and

dissertation, your transcript and diploma will read, "PhD in Biostatistics with a Designated Emphasis in Computational Science and Engineering."

Admission to the University

Minimum Requirements for Admission

The following minimum requirements apply to all graduate programs and will be verified by the Graduate Division:

- 1. A bachelor's degree or recognized equivalent from an accredited institution;
- 2. A grade point average of B or better (3.0);
- 3. If the applicant comes from a country or political entity (e.g., Quebec) where English is not the official language, adequate proficiency in English to do graduate work, as evidenced by a TOEFL score of at least 90 on the iBT test, 570 on the paper-and-pencil test, or an IELTS Band score of at least 7 on a 9-point scale (note that individual programs may set higher levels for any of these); and
- 4. Sufficient undergraduate training to do graduate work in the given field.

Applicants Who Already Hold a Graduate Degree

The Graduate Council views academic degrees not as vocational training certificates, but as evidence of broad training in research methods, independent study, and articulation of learning. Therefore, applicants who already have academic graduate degrees should be able to pursue new subject matter at an advanced level without need to enroll in a related or similar graduate program.

Programs may consider students for an additional academic master's or professional master's degree only if the additional degree is in a distinctly different field.

Applicants admitted to a doctoral program that requires a master's degree to be earned at Berkeley as a prerequisite (even though the applicant already has a master's degree from another institution in the same or a closely allied field of study) will be permitted to undertake the second master's degree, despite the overlap in field.

The Graduate Division will admit students for a second doctoral degree only if they meet the following guidelines:

- 1. Applicants with doctoral degrees may be admitted for an additional doctoral degree only if that degree program is in a general area of knowledge distinctly different from the field in which they earned their original degree. For example, a physics PhD could be admitted to a doctoral degree program in music or history; however, a student with a doctoral degree in mathematics would not be permitted to add a PhD in statistics.
- 2. Applicants who hold the PhD degree may be admitted to a professional doctorate or professional master's degree program if there is no duplication of training involved.

Applicants may apply only to one single degree program or one concurrent degree program per admission cycle.

Required Documents for Applications

- 1. **Transcripts:** Applicants may upload *unofficial* transcripts with your application for the departmental initial review. *If the applicant is admitted*, then *official* transcripts of all college-level work will be required. Official transcripts must be in sealed envelopes as issued by the school(s) attended. If you have attended Berkeley, upload

your unofficial transcript with your application for the departmental initial review. *If you are admitted*, an official transcript with evidence of degree conferral *will not* be required.

- 2. **Letters of recommendation:** Applicants may request online letters of recommendation through the online application system. Hard copies of recommendation letters must be sent directly to the program, not the Graduate Division.
- 3. **Evidence of English language proficiency:** All applicants from countries or political entities in which the official language is not English are required to submit official evidence of English language proficiency. This applies to applicants from Bangladesh, Burma, Nepal, India, Pakistan, Latin America, the Middle East, the People's Republic of China, Taiwan, Japan, Korea, Southeast Asia, most European countries, and Quebec (Canada). However, applicants who, at the time of application, have already completed at least one year of full-time academic course work with grades of B or better at a US university may submit an official transcript from the US university to fulfill this requirement. The following courses will not fulfill this requirement:
 - courses in English as a Second Language,
 - courses conducted in a language other than English,
 - courses that will be completed after the application is submitted, and
 - courses of a non-academic nature.

If applicants have previously been denied admission to Berkeley on the basis of their English language proficiency, they must submit new test scores that meet the current minimum from one of the standardized tests. Official TOEFL score reports must be sent directly from Educational Test Services (ETS). The institution code for Berkeley is 4833. Official IELTS score reports must be mailed directly to our office from British Council. TOEFL and IELTS score reports are only valid for two years.

Where to Apply

Visit the Berkeley Graduate Division application page (<http://grad.berkeley.edu/admissions/apply>).

Unit Requirements

Candidates for this degree are expected to complete 48 units, in four semesters.

Curriculum

Courses Required

STAT 201A	Introduction to Probability at an Advanced Level	4
STAT 201B	Introduction to Statistics at an Advanced Level	4
PB HLTH C240A	Introduction to Modern Biostatistical Theory and Practice	4
PB HLTH C240B	Biostatistical Methods: Survival Analysis and Causality	4
PB HLTH C240C	Biostatistical Methods: Computational Statistics with Applications in Biology and Medicine	4
PB HLTH C240D	Biostatistical Methods: Computational Statistics with Applications in Biology and Medicine II	4
PB HLTH C240E	Statistical Genomics (part 1 of 2)	4
PB HLTH C240F	Statistical Genomics (part 2 of 2)	4
PB HLTH 252D	Introduction to Causal Inference	4
PB HLTH 252E	Advanced Topics in Causal Inference	3

Electives, as per approved study list in the student's research area

MA Comprehensive Examination

The examination for the MA degree is designed to test a candidate's breadth and depth of understanding and knowledge and the ability to articulate and explain the basic concepts gained from the curriculum. The examination committee consists of two faculty members representing both biostatistics and statistics. Candidates are asked to select three topics and write a description of each. Topics are presented during the exam period of 90 minutes. Examiners are free to ask for clarification or elaboration through requests for more background, detail or examples.

MA Thesis

Note that the decision to submit a thesis rather than take the oral comprehensive examination must be made early in the final semester of the program.

Master of Arts/Doctor of Philosophy (MA/PhD)

The MA/PhD degree program requires 4-6 semesters of core course work, submission of a master's thesis (Plan I), followed by 2-4 semesters of course work related to student's interests, completion of the qualifying examination and preparation of the doctoral dissertation. After completion of the MA portion of the degree program, it is straightforward admission to the PhD portion of the degree program. This does not prolong the time to the doctorate since the coursework completed in the first two years is the same for the Biostatistics MA and PhD degrees.

Course Requirements

Students are required to enroll in a minimum of 12 units each semester.

Core Required Courses

STAT 201A	Introduction to Probability at an Advanced Level	4
STAT 201B	Introduction to Statistics at an Advanced Level	4

Take 16 Units from the Biostatistics Core Sequence

PB HLTH C240A	Introduction to Modern Biostatistical Theory and Practice	4
PB HLTH C240B	Biostatistical Methods: Survival Analysis and Causality	4
PB HLTH C240C	Biostatistical Methods: Computational Statistics with Applications in Biology and Medicine	4
PB HLTH C240D	Biostatistical Methods: Computational Statistics with Applications in Biology and Medicine II	4
PB HLTH C240E	Statistical Genomics	4
PB HLTH C240F	Statistical Genomics	4
PB HLTH 252D	Introduction to Causal Inference	4
PB HLTH 252E	Advanced Topics in Causal Inference	3

Core Competencies

MA:

- Understand foundations of statistical inference, e.g., maximum likelihood estimation, regression.
- Have grounding in theoretical framework and ability to apply existing estimators in following categories:
 - a. Computational statistics
 - b. Multivariate analysis

- c. Categorical data analysis
- d. Survival analysis
- e. Longitudinal data analysis
- f. Causal inference
- g. Clinical trials
- h. Statistical genomics
- i. Statistical computing

- Have fluency in statistical programming languages for both analysis using classic methods and implementation of novel methods.
- Identify and apply sound and pertinent methods to address statistical inference questions in biological, public health, and medical research.
- Effectively communicate research findings, orally and in writing.

PhD (in addition to above):

- Develop and apply sound and pertinent methods to address statistical inference questions in biological, public health, and medical research.
- Be able to place scientific questions in rigorous statistical framework:
 - a. Understand and have the ability to apply methods and list assumptions for identifying statistical estimands that address scientific question of interest.
 - b. Be able to either develop estimators for above, or to recognize when such estimands have been developed and have the ability to apply them.
 - c. Have working knowledge of computational methods and programming languages that can be used to implement or evaluate novel methods.
- Have ability to teach statistics at the university level.

Normative Time Requirements

Since there are no unit or course requirements for the PhD, a program of courses appropriate to a student's background and interests may be developed.

All students in the Biostatistics PhD program hold a master's degree in Biostatistics or a related field and those applying for PhD study who do not already hold a masters degree are considered for admission to the Biostatistics MA. This practice does not prolong the time to the doctorate since the first two years of both the MA and PhD programs for students coming from the baccalaureate are identical.

Normative time to advancement: 2-3 years.

Normative time in candidacy: 1-2 years.

Total normative time: 3-5 years.

Time to Advancement

Curriculum

Graduate Biostatistics Electives: 4-6 semesters, as per approved study list, according to research interests and student's background

Graduate Statistics Electives: 4-6 semesters, as per approved study list, according to research interests and student's background

Graduate Electives in another approved subject area (e.g., biology, environmental health, epidemiology): 4-6 semesters, as per approved study list, according to research interests and student's background

Also recommended:

Biostatistical Methods courses (PUB HLTH 240 series)

Intro to Advanced Probability & Statistics (STAT 200 series)

The Qualifying Examination

The oral qualifying examination is scheduled for three hours. The primary purpose of the exam is to test both a candidate's general competence in the field of biostatistics and the ability to apply biostatistical methods to a broad research area. The exam is designed to measure the candidate's breadth of knowledge as well as provide a determination of the candidate's readiness to enter the research phase of study.

To assure the examining committee that the candidate has a firm grasp of both basic areas and a familiarity with current problems in the field, the exam is conducted as follows:

1. The candidate is expected to begin with a 30 minute presentation of a proposed dissertation topic that includes a sound research strategy that the candidate can defend.
2. Following this presentation, the candidate will be asked to demonstrate an ability to synthesize the methods and techniques learned through course work and to apply this knowledge to areas and problems suggested by the committee members. To achieve this goal, committee members are likely to ask questions that delve into subjects that go beyond the chosen area of dissertation research.

Students are encouraged to take the qualifying exam *after they have identified a dissertation adviser and a research topic*. In preparation for the exam, the candidate should meet with the chair of the qualifying examination committee to discuss the details of the structure of the exam and any other pertinent issues.

Time in Candidacy

Dissertation

After completion of course work and the oral comprehensive examination, a doctoral student advances to candidacy for the PhD. Before this is possible, a student must have identified:

1. A dissertation topic
2. A dissertation adviser
3. A committee

Advisers and committee members are particularly interested in working with candidates who have demonstrated an ability to perform original research, and doctoral students are encouraged to explore dissertation research topics early in the program. Topics for research are selected from biostatistics and statistics, public health, biology, computing and other areas (see dissertation topics (<https://www.stat.berkeley.edu/biostat/degrees/dissertation.htm>) of some recent graduates).