



**University of  
Zurich<sup>UZH</sup>**

**Master Program in Biostatistics**

# Study Guide

Version Fall 2018





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## Motivation

Statistical methods for quantitative research have been gaining enormously in importance in science and technology. In biological and life sciences this trend is apparent through the success of relevant journals such as *Biostatistics*, *Bioinformatics*, *Journal of Computational Biology*, *Statistical Methods in Medical Research*.

Biostatistics is the science of analyzing and interpreting biomedical data. Scientific challenges from clinical and biological research require the development and competent application of novel statistical methodology. Currently such challenges emerge, for example, in personalized and evidence-based medicine, in infectious disease and environmental epidemiology, and in the rapidly expanding fields of molecular biology, e.g. genomics, proteomics, epigenomics.

A statistician aiming to be successful at applying methodological developments in the life sciences has to be proficient in a wide variety of modern statistical techniques such as regression of correlated data, treatment of missing values, analysis of longitudinal and event time data, model selection and model validation, to name but a few. To date, however, the Master Program in Biostatistics of the University of Zurich is the only specialized program for the training of biostatisticians in Switzerland.

## 1 Key Features

The Master Program in Biostatistics is a specialized master and is hence open to students with (Bachelor) degrees from different fields with sufficient mathematical and statistical component in the curriculum such as, for example, mathematics, statistics, computer science and physics. The program is designed as a full-time program requiring 90 ECTS credit, which are obtained on average in 3 semesters.

Methodological aspects of statistics are taught in consideration of questions from clinical research and epidemiology. Special emphasis is on recent research topics such as statistical genomics, clinical epidemiology or infectious disease epidemiology. Graduates will therefore be highly qualified for an occupation at universities or research institutes and in the pharmaceutical industry.

The program is offered jointly by the Department of Biostatistics of the Faculty of Medicine and the Institute of Mathematics of the Faculty of Science. The Academic Regulations (Studienordnung) and the Framework Academic Regulations (Rahmenordnung) of the Faculty of Science contain all legally binding regulations; this study guide elaborates on technical structure and admission process. The Faculty of Science awards the degree “Master of Science UZH in Biostatistics” to graduates of the program.

## 2 Structure

### 2.1 Duration

The Master Program in Biostatistics is usually completed in about three semesters, i.e. two semesters of course work, followed by approximately six months for the master thesis. Following the Framework Academic Regulations of the Faculty of Science the master degree has to be completed within at most six semesters (i.e. to a certain extent part-time studies are possible), exceptions to this rule may be granted by the Faculty of Science if compelling reasons exist.

### 2.2 Credit Point Requirements

The required 90 ECTS credits have to be gained from compulsory modules (Pflichtmodule), elective modules in statistics/biostatistics (Wahlpflichtmodule, these can in certain cases be in mathematics) and, elective modules in a field of application (Wahlmodule). Note that one ECTS credits corresponds to approximately 30 hours of work. The following table shows the detailed minimal requirements.

<b>Compulsory modules</b>		
Coursework		33 ECTS
Master's thesis		30 ECTS
Master's exam		5 ECTS
<b>Elective statistical modules</b>		16 ECTS
<b>Elective modules</b>		6 ECTS

### 2.3 Language

All compulsory modules and all elective statistical modules given below are taught in English, some additional statistical courses and some of the possible elective modules may only be offered in German. There will always be enough modules taught in English to obtain the required 90 ECTS credits without knowing German.

## 2.4 Compulsory Modules

The coursework part of the compulsory modules provides knowledge of the core methods of biostatistics and gives a first experience in applying and extending these. It should be completed in the first two semesters of the program and it has to be attended at the University of Zurich. Lectures are in general completed by exercises (LE) and hours per week are divided into lecture and exercise part (e.g. 2+1), half term modules are indicated (1/2). Contents of the compulsory courses can be found on the web site of the program → [www.biostat.uzh.ch](http://www.biostat.uzh.ch).

In the Biostatistics Journal Club biostatistical aspects of recent research papers or monographs are presented by each of the students and discussed together. For the Statistical Consulting module students will work under supervision on selected projects from the consulting service of the Department of Biostatistics and other institutes, they will write a reproducible report and present the results orally. If no appropriate project is available or if there are other reasons the consulting project may be substituted by a term paper. The following table shows the current requirements.

Likelihood Inference	LE 2+1	5 ECTS
Generalized Regression	LE 2+1	5 ECTS
Statistical Methods in Clinical Research	LE 2+1	5 ECTS
Statistical Methods in Epidemiology	LE 2+1	5 ECTS
Survival Analysis	LE 2+1, 1/2	3 ECTS
Biostatistics Journal Club	Seminar	4 ECTS
Statistical Consulting	Project	6 ECTS
Master's thesis	Thesis	30 ECTS
Master's Exam	Exam	5 ECTS

The master's thesis is an independent research activity, which can, for example, be in the framework of an integrative project involving participants from other disciplines. It involves approximately a full-time 6 month workload and is concluded by a written report. A professor, who defines the subject and specifies the submission date, supervises the thesis. It is advisable to start choosing a topic for the master's thesis in the second semester and to complete as much coursework as possible before the thesis work, which should be started at the latest upon the beginning of the third semester.

The master's exam consists of an oral presentation of the master's thesis followed by questions from an expert audience including the supervisor. The student needs to show the ability to clearly present the relevance of the thesis and to defend it in view of critical questions.

## 2.5 Elective Statistical Modules

The elective statistical modules further extend the students knowledge of biostatistical (and statistical) methods. At least 16 ECTS credits have to be gained from selected courses given in the table below. Other appropriate courses at the University of Zurich, the ETH Zurich or another Swiss university may, in agreement with the scientific coordinator, also be taken.

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Statistical Analysis of High-Throughput			
Genomic and Transcriptomic Data	LE 2+1	5 ECTS	every year
Bayesian Data Analysis	LE 2+1	3 ECTS	every 2nd year
Longitudinal Data Analysis	LE 2+1, 1/2	3 ECTS	every 2nd year
Modeling Dependent Data	LE 2+1	5 ECTS	every 2nd year
Advanced R Programming	LE 2+1, 1/2	3 ECTS	every 2nd year
Statistical Methods in Infectious Disease			
Epidemiology	LE 2+1, 1/2	3 ECTS	irregularly
Bayesian Biostatistics	LE 2+1, 1/2	3 ECTS	irregularly

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Ideally most of the elective statistical coursework should be completed in the first two semesters, obtaining some remaining ECTS credits in the third semester in parallel with the master's thesis is possible but the amount should remain limited.

## 2.6 Elective Modules from a Field of Science

The students have the possibility to freely choose appropriate modules from a field of science in which quantitative methods can be applied. At least 6 ECTS credits have to be gained from modules as, for example, "Introduction to Epidemiology" (WBAT 1416), "Molekulare und klassische Genetik für Nicht-Biologiestudierende" (BIO 117), "Evolution" (BIO 113), "Prinzipien des Lebens" (BIO 114), "Proteomics in Biology" (BIO 256), "Virology Principles of Molecular Biology, Pathogenesis, and Control of Human Viruses" (BIO 615). Courses with an exclusively statistical or mathematical content are not admissible in this category, exceptions to this rule may apply. On the web site of the program (→[www.biostat.uzh.ch](http://www.biostat.uzh.ch)) a non-exhaustive list of possible elective modules will be available every semester.

The goal is to gain these ECTS credits during the first or second semester in view of acquiring background knowledge for the topic of the master's thesis. The elective modules have to be in a field for which quantitative methods are meaningful, ideally in the medical or life sciences and they have to be approved by the scientific coordinator.

## 2.7 Study Plan

Students are supposed to compile a study plan outlining which modules they plan to take in which semester and to have it approved by the scientific coordinator. A personal study plan is key to a successful participation in the program. The scientific coordinator will help to establish such a plan. The following table contains an *example* study plan; note that it is not binding (legally binding are only the conditions detailed above).

<b>Semester 1</b> (fall)	26 ECTS	
	<b>Likelihood Inference</b>	5 ECTS
	<b>Generalized Regression</b>	5 ECTS
	<b>Statistical Methods in Clinical Research</b>	5 ECTS
	Statistical Analysis of High-Throughput Genomic and Transcriptomic Data	5 ECTS
	Prinzipien des Lebens	6 ECTS
<b>Semester 2</b> (spring)	26 ECTS	
	<b>Statistical Methods in Epidemiology</b>	5 ECTS
	<b>Survival Analysis</b>	3 ECTS
	<b>Biostatistics Journal Club</b>	4 ECTS
	<b>Statistical Consulting</b>	6 ECTS
	Modeling Dependent Data	5 ECTS
	Bayesian Data Analysis	3 ECTS
<b>Semester 3</b> (fall)	38 ECTS	
	<b>Master's thesis</b>	30 ECTS
	<b>Master's exam</b>	5 ECTS
	<i>Some elective module from ETH Statistics</i>	3 ECTS
	<b>90 ECTS</b>	

Note that starting in the spring will not necessarily mean that semesters 1 and 2 can be inversed since some of the lectures in the spring semester heavily depend on contents of Likelihood Inference, Generalized Regression and Statistical Methods in Clinical Research and hence it will be difficult to take them before those. **As a result starting the program in the spring can lead to longer study times.**

## 2.8 Performance controls

Each module is graded (weighted mean of the grades obtained in the courses a module consists of). Criteria for grading are defined by the responsible of the module. In general, performance controls for courses are written exams of normally 60-120 minutes. Moreover, students usually have to fulfill certain conditions concerning exercises, homework or presentations in order to be admitted to the exam. These conditions are an integral part of the performance control, failing them will lead to failure of the module. Students have passed a performance control if their grade is at least 4 (on the scale from 1 for very unsatisfactory to 6 for excellent, half grades are possible). The 4 ECTS credits for the Biostatistics Journal Club are awarded if students write a sufficient summary of their topic and contribute it to a common document, actively participate during most presentations and present their own topic satisfactorily. The 5 ECTS credits for the master's exam are awarded if the presentation of the master thesis is judged satisfactory and if the student shows sufficient mastery of the subject in the discussion of the presentation. The reports of the Statistical Consulting project and of the master's thesis are graded and the respective ECTS credits are accorded if at least a score of 4 points has been obtained. A performance control, which has not been passed, can be repeated once. If a presentation, a report or the master's thesis is unsatisfactory, a new subject must be chosen for the second attempt. A repeated performance control for a course may be an oral exam. Note that failing an elective module twice has no further consequences except the transcript showing the failures. Failing a compulsory module twice leads to expulsion from the program. Exams can only be repeated in case of failures not to improve the grade.

Examinations take place in calendar weeks 3 and 4 for courses of the fall semester (i.e. approximately two weeks after Christmas break) and calendar weeks 25 and 26 (i.e. approximately two weeks after the end of the spring semester) for courses of the spring semester. Repetitions for failed or missed exams for courses of the fall semester take place in calendar weeks 25 and 26. Repetitions for failed or missed exams for courses of the spring semester take place in calendar weeks 35 and 36, (i.e., approximately last week of August and first week of September).

More information on grades, repetitions, awarding of ECTS credits and the examination process are described in the Framework Academic Regulations of the Faculty of Science.

### 3 Admission

The Master Program in Biostatistics of the University of Zurich is a specialized master program, i.e., potential students come from very diverse backgrounds. Therefore, every application will in a **first step** be evaluated by the admission committee. This process may be completed by a (skype) interview. Depending on the student's background the admission committee decides that the candidate is recommended for one of the following three possibilities:

- Admission without additional requirements: The student will be able to start the program immediately.
- Admission with additional requirements as detailed in the prerequisites. The additional courses have to be passed within the time granted for the master's study. If these requirements are not fulfilled, no degree will be awarded.
- No admission

In a **second step** those applicants who have been selected by the admission committee submit their documents to the Admissions Office of the University of Zurich. In this step degrees and documents will be formally evaluated before registration, hence only for this step certified copies are necessary and an application fee is required.

#### 3.1 Prerequisites

For admission to the program a university degree (bachelor or master), which includes introductions to probability and statistics [9 ECTS], analysis [6 ECTS], and linear algebra [3 ECTS], is required. Most graduates from bachelor programs in mathematics, statistics, computer science and physics will meet or almost meet these requirements. In case an applicant does not meet all requirements, these may be imposed as conditions in addition to the master program's requirements depending on the exact content of each applicant's bachelor (or master) coursework. These can be fulfilled at the beginning of the program. The additional requirements could consist of courses taught in German. Generally, admission is "sur dossier", i.e. taking into account grades, personal statement, and similar aspects.

A list of subjects approximately representing these requirements is given in the appendix below. **It will be assumed that students have an active knowledge of these subjects in all compulsory and many of the statistical elective modules of the program.**

Additionally, some proof that the level of English will be sufficient to follow the lectures is required; this is equivalent to the international C1 language level (mother tongue, previous studies in an English speaking country, secondary education in English at Swiss Matura level, TOEFL, etc.) This requirement might be waived if the candidate can prove an adequate English level in the admission interview.

Most of the courses in the program will be complemented by exercises containing statistical analyses for which the statistical software R ([→www.r-project.org](http://www.r-project.org)) has to be used. Sufficient knowledge in R is presumed from the start of the program. **It is strongly recommended to obtain a working knowledge of R before the start of the program even though no formal proof of this is required.** The scientific coordinator can help in finding an appropriate course in R if desired.

Students with degrees from Universities of Applied Sciences (Fachhochschulen, FH) in relevant disciplines can apply for this master, as for any other master at the University of Zurich, but the minimum average grade required is 5.0 (based on the Swiss Grading System). As for every other master's program they can be admitted provided that the admission to a master's program in the discipline corresponding to the Bachelor would not imply more than 30 ECTS credits additional course requirements. Every FH-Student will have to fulfill additional requirements not exceeding 60 ECTS credits, exact requirements will be decided by the admission committee on a case-by-case basis.

## 3.2 Application

The application for the Master Program in Biostatistics at UZH is a two-step procedure:

1. application to the admission committee (no fee, non-legalized copies of documents are sufficient),
2. only if selected by the admission committee: application to the Admissions Office of UZH (application fee, legalized copies or originals are necessary).

### 3.2.1 First step

To apply to the admission committee of the Master Program in Biostatistics at UZH one needs to compile the following documents

- application form (available on the web site of the program or at [↓ www.biostat.uzh.ch/fileadmin/biostat/user/ApplicationForm.xls](http://www.biostat.uzh.ch/fileadmin/biostat/user/ApplicationForm.xls))
- motivation letter
- complete CV
- complete set of transcripts and diplomas (non-legalized copies are sufficient in the first step)
- detailed description of all undergraduate (and graduate) mathematical classes (not only the title but a least a table of contents, ideally with number of total contact hours and as much information as possible on the grading system for international applicants)
- proof of a sufficient level in English (where applicable)
- one letter of recommendation (sent directly to [masterbiostat@math.uzh.ch](mailto:masterbiostat@math.uzh.ch))

- finance plan (containing costs vs. income, e.g. using budget sheets from Google Docs)
- optional: any additional information that might be relevant for the evaluation of the application (e.g. scientific or technical publications or awards, previous graduate studies, professional experience, reference letters etc.)

Candidates send their **complete application in *one* single pdf file plus the application form in xls format** by email to the address [masterbiostat@math.uzh.ch](mailto:masterbiostat@math.uzh.ch). Applications containing more than these two or different types of documents are not accepted.

For spring semester enrollment applications are expected by September 15 for fall semester enrollment by February 15. Single documents that are not available by the application deadline can be filed subsequently. It is recommended to start the program in the fall semester.

The admission committee will evaluate all applications and roughly one month after the application deadline the candidate will be notified about the decision. Note again that the admission committee can only recommend acceptance for the program to the Admissions Office of the university.

### 3.2.2 Second step

The final decision about a candidate's admission is taken by the Admission Office of the university after checking the documents. Every applicant will be sent an application form in English by the Admissions Office detailing a list of necessary documents and containing further information. Note again that one can only apply at the Admissions Office of the University of Zurich after one has been selected by the admission committee of the Master Program in Biostatistics and after one has been invited by the Admissions Office to do so. Fees are only payable at this second step of the application process, also the form above is only required at this step.

If a candidate will need a visa in order to enter Switzerland it is important that the entire admission process can be completed in time. Towards this goal it is advantageous to check that one fulfils the language requirements (or to do/repeat a test in time) and to prepare necessary documents and legalized copies already before being notified by the admission committee.

## 4 People

### Faculty

Reinhard Furrer	Institute of Mathematics, University of Zurich <b>Managing Director</b>
Leonhard Held	Epidemiology, Biostatistics and Prevention Institute, Department of Biostatistics, University of Zurich <b>Program Director</b>
Torsten Hothorn	Epidemiology, Biostatistics and Prevention Institute, Department of Biostatistics, University of Zurich
Mark Robinson	Institute of Molecular Life Sciences, University of Zurich

### UZH Lecturers

Eva Furrer	Epidemiology, Biostatistics and Prevention Institute, Department of Biostatistics, University of Zurich
Hubert Rehrauer	Functional Genomics Center Zurich
Malgorzata Roos	Epidemiology, Biostatistics and Prevention Institute, Department of Biostatistics, University of Zurich
Beate Sick	Epidemiology, Biostatistics and Prevention Institute, Department of Biostatistics, University of Zurich

### Staff

Eva Furrer	Epidemiology, Biostatistics and Prevention Institute, Department of Biostatistics, University of Zurich <b>Scientific coordinator</b>
Franziska Robmann	Institute of Mathematics, University of Zurich

# Appendix

## Prerequisites

### Analysis (6 ECTS)

- sequences, series, convergence
- basic properties of functions (continuity, monotonicity, ...)
- differential and integral calculus (uni- and multivariate)
- Taylor's Theorem (uni- and multivariate)
- *Landau's notation*

### Linear Algebra (3 ECTS)

- basic operations with vectors and matrices
- rank, determinant, positive definiteness, etc.
- linear combinations, linear independence, orthogonality
- inversion of matrices
- systems of linear equations and connection to matrices
- Cholesky factorization and other decompositions
- *eigenvalues and eigenvectors*

### Probability (part of 9 ECTS)

- events, probabilities and conditional probabilities, independence
- random variables and random vectors
- uni- and multivariate density and distribution function
- expectation, variance, covariance
- expectation and variance of a function of a random variable or vector
- density of a function of a random variable ("change of variables")
- conditional distributions and conditional expectation
- density and distribution function of an i.i.d. sample of observations
- *law of large numbers and central limit theorem*

### Statistics (part of 9 ECTS)

- descriptive statistics (sample mean, variance etc., some graphical displays)
- point estimation methods (MOM, MLE), bias
- concepts of tests of significance
- one- and two-sample standard tests
- interval estimation
- goodness of fit tests
- correlation and simple linear regression
- multivariate regression
- *one-way analysis of variance*

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