

# PUBLIC HEALTH

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 M.S., M.Phil., Ph.D.

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## FIELDS OF STUDY

Programs of study are offered in the areas of biostatistics, chronic disease epidemiology, environmental health sciences, epidemiology of infectious diseases, epidemiology of microbial diseases, health informatics, health policy and management, and social and behavioral sciences.

## SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE

Generally the first two years of the Ph.D. program are devoted primarily to coursework and rotations for students in some areas. All doctoral students are required to successfully complete a minimum of ten graduate-level courses and must satisfy the individual departmental requirements, detailed below. Courses such as Dissertation Research, Preparing for Qualifying Exams, Research Ethics and Responsibility, and Seminar do not count toward the course requirements. However, students must register for these courses in order for them to appear on the transcript.

All first-year Ph.D. students must enroll in and complete training in Research Ethics and Responsibility (EPH 600). This course introduces and prepares students for responsible conduct in research, including data acquisition and management, mentor/trainee responsibilities, publication practices and authorship standards, scientific misconduct, and conflict of interest. Research Ethics and Responsibility is offered annually and is graded Satisfactory/Unsatisfactory.

The Graduate School uses grades of Honors, High Pass, Pass, or Fail. Students are required to earn a grade of Honors in at least two full-term courses and must achieve a High Pass average. (This applies to courses taken after matriculation in the Graduate School and during the nine-month academic year.)

Teaching and research experiences are regarded as an integral aspect of the graduate training program. All students are required to serve as teaching fellows for two terms

at the TF level 10 or 20, typically during years two and three. During the first term of teaching, students must attend a training session conducted by the Poorvu Center for Teaching and Learning. First-year students are encouraged to focus their efforts on coursework and are not permitted to serve as teaching fellows. A Ph.D. student who has fulfilled the teaching requirement is not permitted to serve as a teaching fellow without special permission from their adviser and the DGS. In the rare instances this exception is approved, the student will only be allowed to serve at the TF-10 level.

At the end of years one and two, advisers will be asked to complete a progress report for each student evaluating the student's academic progress and describing the student's readiness for teaching and/or conducting research. This is then discussed with the student and reviewed by the DGS. Students who have not progressed adequately will be asked to meet with the DGS to address the situation.

The qualifying exam is typically taken by the end of the second full academic year. With the assistance of the faculty adviser, generally after qualifying exams, each student requests appropriate faculty members to join a dissertation advisory committee (DAC). The DAC reviews and approves the prospectus as developed by the student and submits it to the DGS and the Graduate Studies Executive Committee (GSEC) for approval. The dissertation prospectus must be approved by the end of the third year.

To be admitted to candidacy, students must: (1) satisfactorily complete the course requirements for their department as outlined below, achieve grades of Honors in at least two full-term courses, and achieve an overall High Pass average; (2) obtain an average grade of High Pass on the qualifying exam; and (3) have the dissertation prospectus approved by the GSEC. Students who have been admitted to candidacy are required by the Graduate School to complete an annual Dissertation Progress Report.

Each DAC is required to meet as a group at least twice each year, and more frequently if necessary. The student schedules meetings of the DAC. The chair/adviser of the DAC produces a summary evaluation of progress and plans for the next six months. The student and the DGS receive a copy of the final document. The DAC reviews the progress of the dissertation research and decides when the dissertation is ready to be submitted to the readers. This decision is based on a closed defense of the dissertation, which involves a formal oral presentation by the student to the DAC. (At the adviser's discretion, other invited faculty may be present.) Upon completion of the closed defense, the chair/adviser of the DAC submits the recommendation to the DGS along with the names of three appropriate readers.

Doctoral dissertations originating in Public Health must also be presented in a public seminar. This presentation is scheduled after the submission of the dissertation to the readers and preferably prior to the receipt and consideration of the readers' reports. At least one member of the DAC supervising the dissertation and at least one member of the GSEC are required to attend the presentation.

## *Required Coursework*

### BIOSTATISTICS

Ph.D. students in biostatistics (BIS) have the choice of two pathways: the *Biostatistics Standard Pathway* and the *Biostatistics Implementation and Prevention Science Methods Pathway*. Students in the Biostatistics Standard Pathway are required to take a

minimum of sixteen courses and students in the Implementation and Prevention Science Methods Pathway are required to take a minimum of fifteen courses (not including BIS 525, BIS 526, BIS 699, and EPH 600). Course substitutions must be identified and approved by the student's adviser and the DGS. Students funded by specific fellowships may be subject to additional requirements and should discuss this with their adviser.

### Core Requirements for Both Pathways

BIS 525	Seminar in Biostatistics and Journal Club <sup>1</sup>	0
BIS 526	Seminar in Biostatistics and Journal Club <sup>1</sup>	0
BIS 610	Applied Area Readings for Qualifying Exams	1
BIS 623	Advanced Regression Models	1
or S&DS 612	Linear Models	
BIS 628	Longitudinal and Multilevel Data Analysis	1
BIS 643	Theory of Survival Analysis	1
BIS 691	Theory of Generalized Linear Models	1
BIS 699	Summer Internship in Biostatistical Research <sup>1</sup>	0
EPH 508	Foundations of Epidemiology and Public Health <sup>2</sup>	1
EPH 600	Research Ethics and Responsibility <sup>1</sup>	0
EPH 608	Frontiers of Public Health <sup>2</sup>	1
S&DS 610	Statistical Inference <sup>3</sup>	1

<sup>1</sup> These courses do not count toward the total number of courses required (fifteen for Implementation and Prevention Science Methods Pathway students and sixteen for Standard Pathway students)

<sup>2</sup> Students entering the program with an M.P.H. degree may be exempt. Students granted an exemption must take an alternate to replace EPH 608.

<sup>3</sup> This course is offered through the Graduate School of Arts and Sciences

Students in the *Standard Pathway* (in consultation with their academic adviser and approved by the DGS) also choose a minimum of eight additional electives that will best prepare them for their dissertation research.

### Implementation and Prevention Science Methods Pathway: Additional Required Courses

BIS 537	Statistical Methods for Causal Inference	1
BIS 629	Advanced Methods for Implementation and Prevention Science	1
BIS 631	Advanced Topics in Causal Inference Methods	1
EMD 533	Implementation Science	1

### Implementation and Prevention Science Methods Pathway: Suggested Electives

BIS 536	Measurement Error and Missing Data	1
BIS 567	Bayesian Statistics	1

BIS 646	Nonparametric Statistical Methods and Their Applications	1
BIS 662	Computational Statistics	1
CDE 516	Principles of Epidemiology II	1
CDE 534	Applied Analytic Methods in Epidemiology	1
EMD 538	Quantitative Methods for Infectious Disease Epidemiology	1
HPM 570	Cost-Effectiveness Analysis and Decision-Making <sup>1</sup>	1
HPM 575	Evaluation of Global Health Policies and Programs	1
HPM 586	Microeconomics for Health Policy and Health Management	1
HPM 587	Advanced Health Economics	1
MGT 611	Policy Modeling <sup>1</sup>	4
SBS 541	Community Health Program Evaluation	1
SBS 574	Developing a Health Promotion and Disease Prevention Intervention	1
SBS 580	Qualitative Research Methods in Public Health <sup>1</sup>	1
S&DS 541	Probability Theory <sup>1,2</sup>	1
S&DS 565	Introductory Machine Learning <sup>2</sup>	1
or S&DS 665	Intermediate Machine Learning	
S&DS 600	Advanced Probability <sup>2</sup>	1

<sup>1</sup> These courses are strongly recommended.

<sup>2</sup> These courses are offered through the Graduate School of Arts and Sciences

#### CHRONIC DISEASE EPIDEMIOLOGY

Ph.D. students in chronic disease epidemiology (CDE) must complete a minimum of seventeen courses (not including EPH 600) from the following courses or their equivalents. Course substitutions must be identified and approved by the student's adviser and the DGS.

CDE 516	Principles of Epidemiology II	1
CDE 534	Applied Analytic Methods in Epidemiology	1
CDE 610	Applied Area Readings for Qualifying Exams	1
CDE 566	Causal Inference Methods in Public Health Research	1
CDE 617	Developing a Research Proposal <sup>1</sup>	1
or EMD 625	How to Develop, Write, and Evaluate an NIH Proposal	
CDE 650	Introduction to Evidence-Based Medicine and Health Care	1
EHS/CDE 502	Physiology for Public Health	1
EPH 508	Foundations of Epidemiology and Public Health <sup>3</sup>	1
EPH 600	Research Ethics and Responsibility <sup>2</sup>	0
EPH 608	Frontiers of Public Health <sup>3</sup>	1

<sup>1</sup> CDE 617 (or EMD 625) is not required of students funded by the Yale AIDS Prevention Training Program. Those students must take an additional elective in order to meet the seventeen-course requirement.

<sup>2</sup> This course does not count toward the minimum of seventeen courses.

<sup>3</sup> Students entering the program with an M.P.H. degree may be exempt. Students granted an exemption must take an alternate course to replace EPH 608.

Alternate courses can be taken to fulfill the requirement of three 600-level course units in Biostatistics. Students must consult with their academic adviser and obtain approval of alternate courses. For example: S&DS 563, Multivariate Statistical Methods for the Social Sciences, may serve as an option for one of these three courses.

Students will also choose five additional electives that will best prepare them for their dissertation research.

**ENVIRONMENTAL HEALTH SCIENCES**

Ph.D. students in environmental health sciences (EHS) must take a minimum of thirteen courses (not including EHS 525, EHS 526, and EPH 600). However, more courses may be required by a student’s adviser. Course substitutions must be identified and approved by the student’s adviser and the DGS.

**Required Courses**

CDE 617	Developing a Research Proposal	1
or EMD 625	How to Develop, Write, and Evaluate an NIH Proposal	
EHS 503	Public Health Toxicology	1
EHS 508	Environmental and Occupational Exposure Science	1
EHS 525	Seminar and Journal Club in Environmental Health <sup>1</sup>	0
EHS 526	Seminar and Journal Club in Environmental Health <sup>1</sup>	0
EHS 560	Methods in Climate Epidemiology	1
or EHS 566	Causal Inference Methods in Public Health Research	
EHS 619	Research Rotation	1
EHS 620	Research Rotation	1
EPH 505	Biostatistics in Public Health	1
EPH 508	Foundations of Epidemiology and Public Health <sup>2</sup>	1
EPH 600	Research Ethics and Responsibility <sup>1</sup>	0
EPH 608	Frontiers of Public Health <sup>2</sup>	1

<sup>1</sup> These courses do not count toward the minimum of thirteen courses.

<sup>2</sup> Students entering the doctoral program with an M.P.H. degree may be exempt. Students granted an exemption must take an alternate course to replace EPH 608.

**Suggested Electives**

A minimum of four is required.

BIS 505	Biostatistics in Public Health II	1
BIS 623	Advanced Regression Models	1
BIS 628	Longitudinal and Multilevel Data Analysis	1
CDE 516	Principles of Epidemiology II	1

CDE/EHS 520	Case-Based Learning for Genetic and Environmental Diseases	1
CDE 534	Applied Analytic Methods in Epidemiology	1
EHS/CDE 502	Physiology for Public Health	1
EHS 511	Principles of Risk Assessment	1
EHS 530	Our Air, Our Health	1
EHS/EMD 537	Water, Sanitation, and Global Health	1
EHS 547	Climate Change and Public Health	1
EHS/CDE 563	Biomarkers of Exposure, Effect, and Susceptibility in the Epidemiology of Noncommunicable Disease	1
EHS 567	Fundamentals of Green Chemistry and Green Engineering	1
EHS 568	Introduction to GIS for Public Health	1
EHS 569	Advanced GIS Workshop	1
EHS 581	Public Health Emergencies: Disaster Planning and Response	1
ENV 755	Modeling Geographic Space <sup>1</sup>	3
ENV 756	Modeling Geographic Objects <sup>1</sup>	3

<sup>1</sup> These courses are offered in the School of the Environment.

#### EPIDEMIOLOGY OF MICROBIAL DISEASES

Ph.D. students in epidemiology of microbial diseases (EMD) must complete a minimum of ten courses (not including EPH 600). Course substitutions must be identified and approved by the student's adviser and the DGS.

Courses in biostatistics, epidemiology, and microbiology are strongly recommended. The specific courses recommended depend on the background of individual students and their stated research interests. An individual program that includes courses, seminars, and research rotations is developed by the student and the student's academic adviser. All students are required to complete three distinct research rotations. These are done in the fall and spring terms and in the summer between the first and second years. These research rotations (EMD 670, EMD 671, and EMD 672) are graded and account for three of the required ten courses.

#### Required Courses

EMD 625 or CDE 617	How to Develop, Write, and Evaluate an NIH Proposal Developing a Research Proposal	1
EMD 670	Advanced Research Laboratories	1
EMD 671	Advanced Research Laboratories	1
EMD 672	Advanced Research Laboratories	1
EPH 508 or CDE 516	Foundations of Epidemiology and Public Health <sup>1</sup> Principles of Epidemiology II	1
EPH 600	Research Ethics and Responsibility <sup>2</sup>	0
EPH 608	Frontiers of Public Health <sup>1</sup>	1

<sup>1</sup> Students entering the program with an M.P.H. or relevant graduate degree may be exempt. Students granted an exemption must take an alternate course to replace EPH 608.

<sup>2</sup> This course does not count toward the minimum of ten courses.

The following courses are suggested as appropriate for Ph.D. students in EMD. However, in consultation with the student's adviser, other courses in the School of Public Health or in other departments may also be appropriate.

BIS 537	Statistical Methods for Causal Inference	1
BIS 567	Bayesian Statistics	1
CDE/EHS 566	Causal Inference Methods in Public Health Research	1
EHS 568	Introduction to GIS for Public Health	1
EMD 531	Genomic Epidemiology of Infectious Diseases	1
EMD 533	Implementation Science	1
EMD 538	Quantitative Methods for Infectious Disease Epidemiology	1
EMD 539	Introduction to the Analysis and Interpretation of Public Health Surveillance Data	1
EMD 546	Vaccines and Vaccine-Preventable Diseases	1
EMD 550	Epidemiology and Control of Vector Borne Diseases	1
EMD 553	Transmission Dynamic Models for Understanding Infectious Diseases	1
EMD 567	Tackling the Big Three: Malaria, TB, and HIV in Resource-Limited Settings	1
EMD 582	Political Epidemiology	1
HPM 570	Cost-Effectiveness Analysis and Decision-Making	1
S&DS 530	Data Exploration and Analysis <sup>1</sup>	1
S&DS 538	Probability and Statistics <sup>1</sup>	1
S&DS 563	Multivariate Statistical Methods for the Social Sciences <sup>1</sup>	1

<sup>1</sup> These courses are offered in through the Graduate School of Arts and Sciences

#### HEALTH POLICY AND MANAGEMENT

Ph.D. students in health policy and management (HPM) are required to develop expertise in one of three areas of specialization: *Economics*; *Organizational Theory and Management*; or *Political and Policy Analysis*.

Students are required to complete the following coursework (or the equivalent in the topic areas covered in these courses). This course listing represents a suggested general program of study, but the specifics of course requirements are adapted to the particular interests and professional aspirations of each student. The standard number of courses taken is sixteen (excluding EPH 600, HPM 617, and HPM 618), with the option of obtaining credits for previous courses. With the approval of the academic adviser and the DGS, alternative courses that better suit the needs of the student may satisfy the coursework requirement. The departmental representative to the GSEC, in conjunction with the student's adviser, is responsible for determining if core course requirements have been satisfied by previous coursework or alternative courses. If so, the student



should apply for a course waiver through the Graduate School. HPM students can only waive up to three of the sixteen courses.

### Core Requirements (All Students)<sup>1</sup>

EPH 508	Foundations of Epidemiology and Public Health <sup>2</sup>	1
EPH 600	Research Ethics and Responsibility <sup>3</sup>	0
EPH 608	Frontiers of Public Health <sup>2</sup>	1
HPM 610	Applied Area Readings	1
HPM 617	Colloquium in Health Services Research <sup>3</sup>	0
HPM 618	Colloquium in Health Services Research <sup>3</sup>	0
HPM 600	Independent Study or Directed Readings <sup>1</sup>	1

<sup>1</sup> Students must enroll in two distinct Independent Study courses (HPM 600)

<sup>2</sup> Students entering the program with an M.P.H. degree may be exempt. Students granted an exemption must take an alternate course to replace EPH 608.

<sup>3</sup> These courses do not count toward the standard number of sixteen courses.

### Methods and Statistics: Suggested Courses

A minimum of four is required.

BIS 623	Advanced Regression Models	1
BIS 628	Longitudinal and Multilevel Data Analysis	1
ECON 556	Topics in Empirical Economics and Public Policy <sup>1</sup>	1
ECON 558	Econometrics <sup>1</sup>	1
HPM 583	Methods in Health Services Research	1
MGMT 737	Applied Empirical Methods <sup>1</sup>	1
PLSC 500	Foundations of Statistical Inference <sup>1</sup>	1
PLSC 503	Theory and Practice of Quantitative Methods <sup>1</sup>	1
SBS 580	Qualitative Research Methods in Public Health	1
SOCY 580	Introduction to Methods in Quantitative Sociology <sup>1</sup>	1
SOCY 581	Intermediate Methods in Quantitative Sociology <sup>1</sup>	1
SOCY 582	Statistics III: Advanced Quantitative Analysis for Social Scientists <sup>1</sup>	1
S&DS 563	Multivariate Statistical Methods for the Social Sciences <sup>1</sup>	1
S&DS 565	Introductory Machine Learning <sup>1</sup>	1

<sup>1</sup> These courses are offered through the Graduate School of Arts and Sciences

### Health Policy and Management: Suggested Courses

A minimum of two, all with Ph.D. readings, is required.

EPH 510	Health Policy and Health Care Systems	1
HPM 514	Health Politics, Governance, and Policy	1
HPM 570	Cost-Effectiveness Analysis and Decision-Making	1

HPM 573	Advanced Topics in Modeling Health Care Decisions	1
HPM 587	Advanced Health Economics	1

### Area of Specialization Course Requirements

A minimum of four courses, all with Ph.D. readings, is required in the student's area of specialization.

### Economics: Required Courses

ECON 545	Microeconomics <sup>2</sup>	1
ECON 558	Econometrics <sup>1,2</sup>	1

<sup>1</sup> ECON 558 may count as a methods/statistics course or as a specialization course, but not both.

<sup>2</sup> These courses are offered through the Graduate School of Arts and Sciences

Students are also required to take a year-long sequence in econometrics, selected in consultation with the student's adviser (this will count towards the required Methods and Statistics courses). In addition, students take *two* field courses in a concentration area in which they plan to develop expertise. Sets of courses across topics can be selected to meet research interests.

### Economics: Concentration Areas and Courses

Other courses may be substituted in consultation with the student's adviser.

#### Behavioral Economics

MGMT 758	Foundations of Behavioral Economics <sup>1</sup>	1
PSYC 553	Behavioral Decision-Making I: Choice <sup>1</sup>	1

#### Industrial Organization

ECON 600	Industrial Organization I <sup>1</sup>	1
ECON 601	Industrial Organization II <sup>1</sup>	1

#### Labor Economics

ECON 630	Labor Economics <sup>1</sup>	1
ECON 631	Labor Economics <sup>1</sup>	1

#### Public Finance

ECON 556	Topics in Empirical Economics and Public Policy <sup>1</sup>	1
ECON 680	Public Finance I <sup>1</sup>	1
ECON 681	Public Finance II <sup>1</sup>	1

### Organizational Theory and Management

Four courses are required, selected in consultation with the student's adviser.

### Political and Policy Analysis: Suggested Courses

Four courses are required, selected in consultation with the student's adviser.

PLSC 800	Introduction to American Politics <sup>1</sup>	1
PLSC 801	Political Preferences and American Political Behavior <sup>1</sup>	1
PLSC 803	American Politics III: Institutions <sup>1</sup>	1

Students will also choose one additional elective that will best prepare them for their dissertation research.

<sup>1</sup> These courses are offered through the Graduate School of Arts and Sciences

## SOCIAL AND BEHAVIORAL SCIENCES

Ph.D. students in social and behavioral sciences (SBS) or the Maternal Child Health Promotion Pathway must complete a minimum of fifteen courses (not including EPH 600) from the following courses or their equivalents. Course substitutions must be identified and approved by the student's adviser and the DGS.

### Core Requirements (All Students)

CDE 617	Developing a Research Proposal <sup>1</sup>	1
or EMD 625	How to Develop, Write, and Evaluate an NIH Proposal	
EPH 508	Foundations of Epidemiology and Public Health <sup>3</sup>	1
EPH 600	Research Ethics and Responsibility <sup>2</sup>	0
EPH 608	Frontiers of Public Health <sup>3</sup>	1
SBS 574	Developing a Health Promotion and Disease Prevention Intervention	1
or SBS 541	Community Health Program Evaluation	
or SBS 593	Community-Based Participatory Research in Public Health	
SBS 580	Qualitative Research Methods in Public Health	1
SBS 610	Applied Area Readings for Qualifying Exams	1
SBS 699	Advanced Topics in Social and Behavioral Sciences	1

<sup>1</sup> CDE 617 (or EMD 625) is not required of students funded by the Yale AIDS Prevention Training Program. Those students must take an additional elective in order to meet the fifteen-course requirement.

<sup>2</sup> This course does not count toward the minimum of fifteen courses.

<sup>3</sup> Students entering the program with an M.P.H. degree may be exempt. Students granted an exception must take an alternate course to replace EPH 608.

In consultation with their dissertation adviser, SBS students (not in the Maternal and Child Health Promotion Pathway) will choose three advanced-level (600 or above) statistics or methods courses from biostatistics, psychology, political science, sociology, anthropology, or statistics and data science (S&DS 563, Multivariate Statistical Methods for the Social Sciences and CDE 516, Principles of Epidemiology II also qualify as statistics or methods courses).

Students must also take five additional electives that will best prepare them for their dissertation research.

### Maternal and Child Health (MCH) Promotion Pathway: Required Courses

These are in addition to SBS core requirements listed above.

EMD 533	Implementation Science	1
HPM 542	Health of Women and Children	1
SBS 594	Maternal-Child Public Health Nutrition	1

### **MCH Promotion Pathway: Required Electives**

Any *three* from this list and *two* additional electives chosen in consultation with the student's adviser.

BIS 505	Biostatistics in Public Health II	1
BIS 621	Regression Models for Public Health	1
or BIS 623	Advanced Regression Models	
BIS 628	Longitudinal and Multilevel Data Analysis	1
BIS 630	Applied Survival Analysis	1
CDE 516	Principles of Epidemiology II	1
CDE 566	Causal Inference Methods in Public Health Research	1
or EMD 582	Political Epidemiology	
EPH 505	Biostatistics in Public Health	1
HPM 575	Evaluation of Global Health Policies and Programs	1
S&DS 563	Multivariate Statistical Methods for the Social Sciences	1

## **M.D.-PH.D. PROGRAM REQUIREMENTS FOR PUBLIC HEALTH**

All M.D.-Ph.D. students must meet with the director of graduate studies (DGS) in public health, if they are considering affiliating with public health. Students in this program are expected to meet the guidelines listed below in the time frame outlined. The DGS must approve any variations to these requirements.

### *Teaching*

One term of teaching is required. If students are approved by the DGS to teach beyond this requirement, they can be compensated. In the rare instance that teaching beyond the requirement is approved, the student will only be allowed to serve as a TF 10. If a student has served as a teaching fellow elsewhere on campus, this experience may be counted toward the requirement. DGS approval is required to waive the teaching requirement on the basis of previous Yale teaching experience.

### *Rotations/Internships*

Students should do two rotations/internships with potential advisers in public health. The purpose of these rotations/internships is to learn research approaches and methodologies and/or to allow the student time to determine if the faculty's research interests are compatible with the student's research interests. These rotations/internships are usually done during the summer between the first and second years of medical school. In some cases, students may need to defer this requirement until the summer after the second year after taking certain courses and/or completing readings in order to possess the background necessary for a successful rotation/internship.

## *Required Coursework*

M.D.-Ph.D. students are generally expected to take the same courses as traditional Ph.D. students. Departmental requirements vary; therefore, students should confer with the DGS and their Ph.D. adviser.

## *Timeline for Qualifying Exam*

Students generally will take medical school courses in years one and two. Students can take public health courses or other appropriate courses during this time, if scheduling allows. Once affiliated with the public health program, students will complete all course requirements for the department. This generally takes a minimum of two terms but can take up to four terms after affiliating with public health. The qualifying exam is commonly completed after the fourth term of affiliation with the Ph.D. program in public health, but it can be done earlier with approval of the Ph.D. adviser and the DGS.

## *Prospectus Timeline*

Following completion of the qualifying exam, students should focus on the prospectus, which must be approved by the Public Health Graduate Studies Executive Committee (GSEC) before the end of the student's sixth term as an affiliated Ph.D. student in public health.

## *Admission to Candidacy*

To be admitted to candidacy, students must: (1) satisfactorily complete the course requirements for their department as outlined above, achieve grades of Honors in at least two full-term courses, and achieve an overall High Pass average; (2) obtain an average grade of High Pass on the qualifying exam; and (3) have the dissertation prospectus approved by the GSEC. All M.D.-Ph.D. students must be admitted to candidacy before the start of their fourth year in the Ph.D. program (i.e., before the start of the seventh term).

## **MASTER'S DEGREES**

**M.Phil.** The M.Phil. is awarded to doctoral students who have advanced to candidacy. When students advance to candidacy, the registrar's office automatically submits a petition for the awarding of the M.Phil. degree.

**Terminal Master's Degree Program** The school offers a terminal master's degree program leading to an M.S. in public health in four concentrations: biostatistics (a two-year program), chronic disease epidemiology (a one-year program), epidemiology of infectious diseases (a one-year program), and health informatics (a two-year program). All students must fulfill both the departmental and Graduate School requirements for a terminal M.S. degree.

Students must have an overall grade average of High Pass, including a grade of Honors in at least one full-term graduate course (for students enrolled in the one-year programs in chronic disease epidemiology and epidemiology of infectious diseases) or in at least two full-term graduate courses (for students enrolled in the two-year programs in biostatistics and health informatics). In order to maintain the minimum average of High Pass, each grade of Pass must be balanced by one grade of Honors.

For more details, please see Course and Honors Requirements under Policies and Regulations.

A biostatistics, chronic disease epidemiology, or epidemiology of microbial diseases student who is withdrawing from the Ph.D. program, and has successfully completed all required coursework for the terminal M.S. degree (described below), may apply and be recommended for the M.S. in public health. In the other departments, students must have successfully completed (prior to withdrawal) at least ten courses in the doctoral program and a capstone experience, achieving a minimum of two Honors grades and an overall High Pass average. Students who withdraw after qualifying or receiving the M.Phil. are not eligible for an M.S. degree.

*Fields of Study*

**TERMINAL M.S. WITH CONCENTRATION IN BIOSTATISTICS**

The M.S. with a concentration in biostatistics is a two-year program that provides training in clinical trials, epidemiologic methodology, implementation science, data science, statistical genetics, and mathematical models for infectious diseases. Students have a choice of three pathways: the *Biostatistics Standard Pathway*, the *Biostatistics Implementation and Prevention Science Methods Pathway*, and the *Biostatistics Data Science Pathway*. In contrast to the more general M.P.H. degree, the M.S. degree emphasizes the mastery of biostatistical skills from the beginning of the plan of study. While graduates of this program may apply to the Ph.D. degree program, the M.S. degree is itself quite marketable as a terminal degree. Part-time enrollment is permitted.

**Degree Requirements**

The biostatistics concentration requires the completion of fifteen required and elective courses for the Standard Pathway and the Implementation and Prevention Sciences Pathway. Sixteen required and elective courses must be completed for the Data Science Pathway. These requirements exclude the Seminar, BIS 525/BIS 526; the Summer Internship, BIS 695; EPH 100; and EPH 101.

NOTE: Half-term courses cannot count as an elective unless an additional half-term course is taken and the biostatistics faculty have approved both courses as an elective.

The Graduate School requires an overall grade average of High Pass, including grades of Honors in at least two full-term graduate courses for students enrolled in a two-year program. In order to maintain the minimum average of High Pass, each grade of Pass on the student’s transcript must be balanced by one grade of Honors. Each grade of Fail must be balanced by two grades of Honors. If a student retakes a course in which the student has received a failing grade, only the newer grade will be considered in calculating this average. The initial grade of Fail, however, will remain on the student’s transcript. A grade awarded at the conclusion of a full-year course in which no grade is awarded at the end of the first term would be counted twice in calculating this average.

**Curriculum**

**Required Courses for All Pathways** (or substitutions approved by the student’s adviser and the DGS)

BIS 525	Seminar in Biostatistics and Journal Club <sup>1</sup>	o
BIS 526	Seminar in Biostatistics and Journal Club <sup>1</sup>	o

BIS 623	Advanced Regression Models	1
or S&DS 612	Linear Models	
BIS 628	Longitudinal and Multilevel Data Analysis	1
BIS 630	Applied Survival Analysis	1
or BIS 643	Theory of Survival Analysis	
BIS 678	Statistical Practice I	1
BIS 695	Summer Internship in Biostatistics <sup>1</sup>	0
EPH 100	Professional Skills Series <sup>1</sup>	0
EPH 101	Professional Skills Series <sup>1</sup>	0
EPH 509	Fundamentals of Epidemiology	1
EPH 608	Frontiers of Public Health <sup>2</sup>	1
S&DS 541	Probability Theory	1
or S&DS 551	Stochastic Processes	
or S&DS 600	Advanced Probability	
S&DS 542	Theory of Statistics	1
or S&DS 610	Statistical Inference	

<sup>1</sup> These courses do not count toward the fifteen required courses.

<sup>2</sup> Students entering the program with an M.P.H. or relevant graduate degree may be exempt.

#### **Additional Required Courses: Standard Pathway**

BIS 679	Advanced Statistical Programming in SAS and R	1
BIS 681	Statistical Practice II <sup>1</sup>	1
or BIS 649	Master's Thesis Research	
or BIS 650	Master's Thesis Research	

A minimum of two of the following biostatistics electives:

BIS 536	Measurement Error and Missing Data	1
BIS 537	Statistical Methods for Causal Inference	1
BIS 540	Fundamentals of Clinical Trials	1
BIS 550	Topics in Biomedical Informatics and Data Science	1
BIS 555	Machine Learning with Biomedical Data	1
BIS 560	Introduction to Health Informatics	1
BIS 567	Bayesian Statistics	1
BIS 568	Applied Artificial Intelligence in Healthcare	1
BIS 620	Data Science Software Systems	1
BIS 629	Advanced Methods for Implementation and Prevention Science	1
BIS 631	Advanced Topics in Causal Inference Methods	1
BIS 633	Population and Public Health Informatics	1
BIS 634	Computational Methods for Informatics	1

BIS 638	Clinical Database Management Systems and Ontologies	1
BIS 640	User-Centered Design of Digital Health Tools	1
BIS 643	Theory of Survival Analysis <sup>2</sup>	1
BIS 645	Statistical Methods in Human Genetics	1
BIS 646	Nonparametric Statistical Methods and Their Applications	1
BIS 662	Computational Statistics	1
BIS 691	Theory of Generalized Linear Models	1
BIS 692	Statistical Methods in Computational Biology	1

Additional electives must be approved by the Standard Pathway faculty liaison

<sup>1</sup> MS Biostatistics (Standard Pathway) students are required to complete a two-semester capstone experience in the second year. This requirement can be fulfilled by:

- Taking two semesters of the capstone course: BIS 678 (fall) and BIS 681 (spring); *or*
- Taking the fall semester capstone course BIS 678 and completing a thesis. The thesis is a yearlong project. Students who plan to complete a thesis should register for BIS 649 (fall; 1 credit) and BIS 650 (spring; 1 credit).

All students who complete a thesis will be required to present their research during a public seminar to the Biostatistics faculty and students in order to graduate.

<sup>2</sup> Cannot fulfill elective if substituted for BIS 630.

A minimum of three electives must be taken from either the Biostatistics electives list or the list below:

CDE 566	Causal Inference Methods in Public Health Research	1
CDE 634	Advanced Applied Analytic Methods in Epidemiology and Public Health	1
CPSC 540	Database Design and Implementation	1
CPSC 546	Data and Information Visualization	1
CPSC 552	Deep Learning Theory and Applications	1
CPSC 570	Artificial Intelligence	1
CPSC 577	Natural Language Processing	1
CPSC 582	Current Topics in Applied Machine Learning	1
CPSC 583	Deep Learning on Graph-Structured Data	1
CPSC 640	Topics in Numerical Computation	1
CPSC 670	Topics in Natural Language Processing	1
CPSC 677	Advanced Natural Language Processing	1
CPSC 680	Trustworthy Deep Learning	1
CPSC 752	Biomedical Data Science: Mining and Modeling	1
ECON 554	Econometrics V	1
EMD 553	Transmission Dynamic Models for Understanding Infectious Diseases	1
ENAS 912	Biomedical Image Processing and Analysis	1
HPM 573	Advanced Topics in Modeling Health Care Decisions	1



HPM 583	Methods in Health Services Research	1
INP 558	Computational Methods in Human Neuroscience	1
INP 599	Statistics and Data Analysis in Neuroscience	1
MGT 803	Decision Making with Data <sup>1</sup>	2
S&DS 517	Applied Machine Learning and Causal Inference	1
S&DS 551	Stochastic Processes	1
S&DS 562	Computational Tools for Data Science	1
S&DS 563	Multivariate Statistical Methods for the Social Sciences	1
S&DS 565	Introductory Machine Learning	1
S&DS 569	Numerical Linear Algebra: Deterministic and Randomized Algorithms	1
S&DS 580	Neural Data Analysis	1
S&DS 600	Advanced Probability	1
S&DS 610	Statistical Inference	1
S&DS 611	Selected Topics in Statistical Decision Theory	1
S&DS 612	Linear Models <sup>2</sup>	1
S&DS 618	Asymptotic Statistics	1
S&DS 625	Statistical Case Studies	1
S&DS 631	Optimization and Computation	1
S&DS 632	Advanced Optimization Techniques	1
S&DS 661	Data Analysis	1
S&DS 662	Statistical Computing	1
S&DS 663	Computational Mathematics Situational Awareness and Survival Skills	1
S&DS 664	Information Theory	1
S&DS 665	Intermediate Machine Learning	1
S&DS 674	Applied Spatial Statistics	1
S&DS 685	Theory of Reinforcement Learning	1
Additional electives must be approved by the Standard Pathway faculty liaison		

<sup>1</sup> These courses are offered in the School of Management

<sup>2</sup> Cannot fulfill elective credit if substituted for BIS 623.

Students wishing to complete a thesis may enroll in BIS 649 and BIS 650, Master's Thesis Research. This would be an additional requirement and cannot replace any of the required courses noted above. All students who complete a thesis will be required to present their research during a public seminar to the Biostatistics faculty and students in order to graduate.

### **Additional Required Courses: Implementation and Prevention Science Methods Pathway**

BIS 629	Advanced Methods for Implementation and Prevention Science	1
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BIS 679	Advanced Statistical Programming in SAS and R	1
BIS 681	Statistical Practice II <sup>1</sup>	1
or BIS 649	Master's Thesis Research	
or BIS 650	Master's Thesis Research	
EMD 533	Implementation Science	1

<sup>1</sup> MS Biostatistics (Implementation Science Pathway) students are required to complete a two-semester capstone experience in the second year. This requirement can be fulfilled by:

- Taking two semesters of the capstone course: BIS 678 (fall) and BIS 681 (spring); *or*
- Taking the fall semester capstone course BIS 678 and completing a thesis. The thesis is a yearlong project. Students who plan to complete a thesis should register for: BIS 649 (fall; 1 credit) and BIS 650 (spring; 1 credit).

Students in this pathway are strongly encouraged to complete a thesis. All students who complete a thesis will be required to present their research during a public seminar to the Biostatistics faculty and students in order to graduate.

At least one of the following:

BIS 536	Measurement Error and Missing Data	1
BIS 537	Statistical Methods for Causal Inference	1
BIS 631	Advanced Topics in Causal Inference Methods	1

At least two of the following:

CDE 516	Principles of Epidemiology II	1
CDE 534	Applied Analytic Methods in Epidemiology	1
EMD 538	Quantitative Methods for Infectious Disease Epidemiology	1
HPM 570	Cost-Effectiveness Analysis and Decision-Making <sup>1</sup>	1
HPM 575	Evaluation of Global Health Policies and Programs	1
HPM 586	Microeconomics for Health Policy and Health Management	1
HPM 587	Advanced Health Economics	1
MGT 611	Policy Modeling	4
SBS 541	Community Health Program Evaluation <sup>1</sup>	1
SBS 574	Developing a Health Promotion and Disease Prevention Intervention	1
SBS 580	Qualitative Research Methods in Public Health <sup>1</sup>	1
S&DS 565	Introductory Machine Learning	1
Alternative electives must be approved by the Implementation Science Pathway director.		

<sup>1</sup> These courses are highly recommended.

#### **Additional Required Courses: Data Science Pathway**

BIS 620	Data Science Software Systems	1
BIS 687	Data Science Capstone <sup>1</sup>	1

or BIS 649	Master's Thesis Research
or BIS 650	Master's Thesis Research

<sup>1</sup> MS Biostatistics (Data Science Pathway) students are required to complete a two-semester capstone experience in the second year. This requirement can be fulfilled by:

- Taking two semesters of the capstone course: BIS 678 (fall) and BIS 687 (spring); *or*
- Taking the fall semester capstone course BIS 678 and completing a thesis. The thesis is a yearlong project. Students who plan to complete a thesis should register for BIS 649 (fall; 1 credit) and BIS 650 (spring; 1 credit).

All students who complete a thesis will be required to present their research during a public seminar to the Biostatistics faculty and students in order to graduate.

Two of the following biostatistics, computer science, or statistical methods courses

BIS 536	Measurement Error and Missing Data	1
BIS 537	Statistical Methods for Causal Inference	1
BIS 540	Fundamentals of Clinical Trials	1
BIS 550	Topics in Biomedical Informatics and Data Science	1
BIS 555	Machine Learning with Biomedical Data <sup>1</sup>	1
BIS 567	Bayesian Statistics	1
BIS 629	Advanced Methods for Implementation and Prevention Science	1
BIS 634	Computational Methods for Informatics <sup>1</sup>	1
BIS 645	Statistical Methods in Human Genetics	1
BIS 646	Nonparametric Statistical Methods and Their Applications	1
BIS 662	Computational Statistics <sup>1</sup>	1
BIS 692	Statistical Methods in Computational Biology	1
CB&B 562	Modeling Biological Systems II	1
CB&B 752	Biomedical Data Science: Mining and Modeling	1
CPSC 519	Full Stack Web Programming	1
CPSC 526	Building Distributed Systems	1
CPSC 539	Software Engineering	1
CPSC 565	Theory of Distributed Systems	1
CPSC 577	Natural Language Processing	1
CPSC 588	AI Foundation Models	1
CPSC 640	Topics in Numerical Computation	1
CPSC 642	Modern Challenges in Statistics: A Computational Perspective	1
EMD 553	Transmission Dynamic Models for Understanding Infectious Diseases	1
HPM 573	Advanced Topics in Modeling Health Care Decisions	1
S&DS 541	Probability Theory <sup>3</sup>	1
S&DS 551	Stochastic Processes <sup>4</sup>	1

S&DS 611	Selected Topics in Statistical Decision Theory	1
S&DS 625	Statistical Case Studies	1
S&DS 661	Data Analysis	1
S&DS 664	Information Theory	1
Additional electives must be approved by the Data Science Pathway director		

One of the following Machine Learning courses:

BIS 555	Machine Learning with Biomedical Data <sup>1</sup>	1
BIS 568	Applied Artificial Intelligence in Healthcare	1
BIS 634	Computational Methods for Informatics <sup>1</sup>	1
BIS 662	Computational Statistics <sup>1</sup>	1
BIS 691	Theory of Generalized Linear Models	1
CB&B 555	Unsupervised Learning for Big Data	1
CB&B 663	Deep Learning Theory and Applications	1
CPSC 569	Randomized Algorithms	1
CPSC 583	Deep Learning on Graph-Structured Data	1
CPSC 644	Geometric and Topological Methods in Machine Learning	1
CPSC 670	Topics in Natural Language Processing	1
S&DS 517	Applied Machine Learning and Causal Inference	1
S&DS 562	Computational Tools for Data Science	1
S&DS 565	Introductory Machine Learning	1
S&DS 569	Numerical Linear Algebra: Deterministic and Randomized Algorithms	1
S&DS 631	Optimization and Computation	1
S&DS 632	Advanced Optimization Techniques	1
S&DS 665	Intermediate Machine Learning	1
S&DS 674	Applied Spatial Statistics	1
S&DS 684	Statistical Inference on Graphs	1
S&DS 685	Theory of Reinforcement Learning	1
S&DS 686	High-Dimensional Phenomena in Statistics and Learning	1
Additional electives must be approved by the Data Science Pathway director		

One of the following Database courses:

BIS 550	Topics in Biomedical Informatics and Data Science <sup>1</sup>	1
BIS 638	Clinical Database Management Systems and Ontologies	1
BIS 679	Advanced Statistical Programming in SAS and R	1
CPSC 537	Database Systems	1
MGT 656	Management of Software Development <sup>2</sup>	4
MGT 660	Advanced Management of Software Development <sup>2</sup>	4
Additional electives must be approved by the Data Science Pathway director		

<sup>1</sup> These courses can only be counted to fulfill the requirement of one category; they cannot be counted twice.

<sup>2</sup> These courses are offered at the School of Management.

<sup>3</sup> Cannot fulfill elective if taken as a requirement

<sup>4</sup> Cannot fulfill elective if taken as a substitute for S&DS 541

Two additional electives are required from the biostatistics, machine learning, or database list. Other courses from public health or other departments must be approved by the Data Science Pathway faculty liaison.

### **Competencies**

Upon receiving an M.S. in the biostatistics concentration of public health, the student will be able to:

- Select from a variety of analytical tools to test statistical hypotheses, interpret results of statistical analyses, and use these results to make relevant inferences from data.
- Design efficient computer programs for study management, statistical analysis, as well as presentation using R, SAS, and other programming languages.
- Demonstrate oral and written communication and presentation skills to effectively communicate and disseminate results to professional audiences.

### **TERMINAL M.S. WITH CONCENTRATION IN CHRONIC DISEASE EPIDEMIOLOGY**

This one-year program is designed for medical and health care professionals (e.g., M.D., Ph.D., D.V.M., D.D.S., D.M.D.) or others seeking the skills necessary to conduct epidemiological research in their professional practice. Part-time enrollment is permitted.

### **Degree Requirements**

The chronic disease epidemiology concentration consists of required and elective coursework and satisfactory completion of the capstone experience. A total of ten courses is required (excluding the Seminar, CDE 525/CDE 526). It is expected that this program will be completed during a single academic year when a student enrolls full-time. Students with an M.P.H. or relevant graduate degree may be eligible to substitute advanced courses for some of the required courses. Written permission of the DGS is required prior to enrolling in substitute courses.

The Graduate School requires an overall grade average of High Pass, including a grade of Honors in at least one full-term graduate course for students enrolled in a one-year program. In order to maintain the minimum average of High Pass, each grade of Pass on the student's transcript must be balanced by one grade of Honors. Each grade of Fail must be balanced by two grades of Honors. If a student retakes a course in which the student has received a failing grade, only the newer grade will be considered in calculating this average. The initial grade of Fail, however, will remain on the student's transcript. A grade awarded at the conclusion of a full-year course in which no grade is awarded at the end of the first term would be counted twice in calculating this average.

### **Curriculum**

#### **Required Courses (or approved substitutions)**

CDE 516	Principles of Epidemiology II	1
CDE 525	Seminar in Chronic Disease Epidemiology <sup>1</sup>	0
CDE 526	Seminar in Chronic Disease Epidemiology <sup>1</sup>	0
CDE 617	Developing a Research Proposal <sup>2</sup>	1
or CDE 600	Independent Study or Directed Readings	
or EMD 625	How to Develop, Write, and Evaluate an NIH Proposal	
EPH 508	Foundations of Epidemiology and Public Health	1
EPH 608	Frontiers of Public Health <sup>3</sup>	1

<sup>1</sup> These courses do not count toward the ten required courses.

<sup>2</sup> In the capstone courses CDE 617 or EMD 625, the student is required to develop a grant application that is deemed reasonably competitive by the instructor. An alternative to one of these capstone courses, is an individualized tutorial (CDE 600), in which the student completes a manuscript that is suitable for submission for publication in a relevant journal.

<sup>3</sup> Students entering the program with an M.P.H. or relevant graduate degree may be exempt.

**Quantitative courses** (choose three from the following or an approved substitution)

BIS 536	Measurement Error and Missing Data	1
BIS 537	Statistical Methods for Causal Inference	1
BIS 575	Introduction to Regulatory Affairs	1
BIS 621	Regression Models for Public Health	1
BIS 630	Applied Survival Analysis	1
BIS 633	Population and Public Health Informatics	1
S&DS 530	Data Exploration and Analysis	1
S&DS 563	Multivariate Statistical Methods for the Social Sciences	1

**Chronic Disease Epidemiology** (choose two of the following)

CDE 502	Physiology for Public Health	1
CDE 532	Epidemiology of Cancer	1
CDE 534	Applied Analytic Methods in Epidemiology	1
CDE 535	Epidemiology of Heart Disease and Stroke	1
CDE 545	Health Disparities by Race and Social Class: Application to Chronic Disease Epidemiology	1
CDE 551	Global Noncommunicable Disease	1
CDE 562	Nutrition and Chronic Disease	1
CDE 572	Obesity Prevention and Lifestyle Interventions	1
CDE 582	Health Outcomes Research: Matching the Right Research Question to the Right Data	1
CDE 588	Perinatal Epidemiology	1

CDE 597	Genetic Concepts in Public Health	1
CDE 650	Introduction to Evidence-Based Medicine and Health Care	1

Students must complete one additional elective, chosen in consultation with their adviser.

### Competencies

Upon receiving an M.S. in the chronic disease epidemiology concentration of public health, the student will be able to:

- Evaluate the scientific merit and feasibility of epidemiologic study designs.
- Review and evaluate epidemiologic reports and research articles.
- Analyze data and draw appropriate inferences from epidemiologic studies.
- Write an epidemiologic research proposal.

### TERMINAL M.S. WITH CONCENTRATION IN EPIDEMIOLOGY OF INFECTIOUS DISEASES

This one-year program offers two areas of specialization: a quantitative area aims to provide quantitatively focused research training in the epidemiology of infectious diseases, focusing on the analysis of communicable disease data as well as modeling and simulation; and a clinical area aims to provide research training for clinicians and clinical trainees interested in furthering their research expertise. Part-time enrollment is permitted. Part-time students must complete the degree requirements in two years.

### Degree Requirements

The epidemiology of infectious diseases concentration requires a total of ten courses (excluding the yearlong Seminar, EMD 525/EMD 526), including satisfactory completion of the capstone course. There are two capstone course options:

**Option 1** Students may elect to enroll in EMD 625, How to Develop, Write, and Evaluate an NIH Proposal. Students in this course develop an NIH-style research proposal focusing on a topic related to infectious disease epidemiology. This course is taken by students in the final term of their M.S. program. Students meet as a group for cross-cutting didactic sessions on reading RFAs, NIH peer review and scoring, and effective grant writing and grantsmanship. Students work one-on-one outside of these sessions with faculty mentors to construct their grant proposals over the course of the term. They work with other students in the course to refine their projects and will do an oral presentation of their proposal at the final capstone course symposium at the end of the term.

**Option 2** Students may elect to enroll in EMD 563, Laboratory and Field Studies in Infectious Diseases. This course provides students with hands-on training in laboratory or epidemiological research techniques. Students work one-on-one with faculty members on existing or new projects. Students choosing this option write-up and present their findings at the final capstone course symposium at the end of their final term.

The Graduate School requires an overall grade average of High Pass, including a grade of Honors in at least one full-term graduate course for students enrolled in a one-year program. In order to maintain the minimum average of High Pass, each grade of Pass

on the student's transcript must be balanced by one grade of Honors. Each grade of Fail must be balanced by two grades of Honors. If a student retakes a course in which the student has received a failing grade, only the newer grade will be considered in calculating this average. The initial grade of Fail, however, will remain on the student's transcript. A grade awarded at the conclusion of a full-year course in which no grade is awarded at the end of the first term would be counted twice in calculating this average.

### Curriculum

**Required Courses: Quantitative Specialization** (or substitutions approved by the student's adviser and the DGS)

BIS 623	Advanced Regression Models	1
BIS 630	Applied Survival Analysis	1
EMD 517	Principles of Infectious Diseases I	1
EMD 518	Principles of Infectious Diseases II	1
EMD 525	Seminar in Epidemiology of Microbial Diseases <sup>1</sup>	0
EMD 526	Seminar in Epidemiology of Microbial Diseases <sup>1</sup>	0
EMD 538	Quantitative Methods for Infectious Disease Epidemiology	1
EMD 553	Transmission Dynamic Models for Understanding Infectious Diseases	1
or EMD 539	Introduction to the Analysis and Interpretation of Public Health Surveillance Data	
EMD 625	How to Develop, Write, and Evaluate an NIH Proposal	1
or EMD 563	Laboratory and Field Studies in Infectious Diseases	
EPH 508	Foundations of Epidemiology and Public Health	1
EPH 608	Frontiers of Public Health (EPH 600 no longer required for MS students) <sup>2</sup>	1

<sup>1</sup> These courses do not count toward the ten required courses.

<sup>2</sup> Students entering the program with an M.P.H. or relevant graduate degree may be exempt.

In addition, students must complete one elective course in epidemiology of infectious diseases (approved by the student's adviser and the DGS).

**Required Courses: Clinical Specialization** (or substitutions approved by the student's adviser and the DGS)

BIS 505	Biostatistics in Public Health II	1
or CDE 534	Applied Analytic Methods in Epidemiology	
EMD 517	Principles of Infectious Diseases I	1
EMD 518	Principles of Infectious Diseases II	1
EMD 525	Seminar in Epidemiology of Microbial Diseases <sup>1</sup>	0
EMD 526	Seminar in Epidemiology of Microbial Diseases <sup>1</sup>	0
EMD 530	Health Care Epidemiology: Improving Health Care Quality through Infection Prevention	1
or EMD 536	Outbreak Investigations: Principles and Practice	



EMD 567	Tackling the Big Three: Malaria, TB, and HIV in Resource-Limited Settings	1
or EMD 533	Implementation Science	
EMD 625	How to Develop, Write, and Evaluate an NIH Proposal	1
or EMD 563	Laboratory and Field Studies in Infectious Diseases	
EPH 505	Biostatistics in Public Health	1
EPH 508	Foundations of Epidemiology and Public Health	1
EPH 608	Frontiers of Public Health <sup>2</sup>	1

<sup>1</sup> These courses do not count toward the ten required courses.

<sup>2</sup> Students entering the program with an M.P.H. or relevant graduate degree may be exempt.

In addition, students must complete one elective course in epidemiology of infectious diseases (approved by the student's adviser and the DGS).

### **Suggested Electives for Both Specializations**

EMD 531	Genomic Epidemiology of Infectious Diseases	1
EMD 537	Water, Sanitation, and Global Health	1
EMD 541	Health in Humanitarian Crises	1
EMD 546	Vaccines and Vaccine-Preventable Diseases	1
EMD 580	Reforming Health Systems: Using Data to Improve Health in Low- and Middle-Income Countries	1
EMD 582	Political Epidemiology	1

Alternate electives must be approved in consultation with the student's adviser and the DGS.

### **Competencies**

Upon receiving an M.S. in the epidemiology of infectious diseases concentration of public health, the student will be able to:

- Explain the role of quantitative and qualitative methods and sciences in describing and assessing a population's health (especially in terms of risk/burden of infectious diseases).
- Explain ecological perspective on the connection between human health, animal health, and ecosystem health with respect to microbial threats.
- Analyze datasets that arise in the context of outbreaks, epidemics, and endemic infectious diseases. (Quantitative specialization only)
- Design observational and/or experimental studies to study the relationship between host, microbial, or environmental factors on the occurrence or control of infectious diseases. (Clinical specialization only)

### **TERMINAL M.S. WITH CONCENTRATION IN HEALTH INFORMATICS**

This two-year program provides well-rounded training in health informatics, with a balance of core courses from such areas as information sciences, clinical informatics, clinical research informatics, consumer health and population health informatics,

and data science, and more broadly health policy, social and behavioral science, biostatistics, and epidemiology. First-year courses survey the field; the typical second-year courses are more technical and put greater emphasis on mastering the skills in health informatics. Part-time enrollment is not permitted.

**Degree Requirements**

The health informatics concentration consists of a total of fourteen courses: eight required courses, four electives, and satisfactory completion and presentation of a yearlong capstone project. Students demonstrating a mastery of topics covered by the required courses may replace them with more advanced courses but must receive written permission from the DGS and their adviser prior to enrolling in the substitute courses.

The Graduate School requires an overall grade average of High Pass, including grades of Honors in at least two full-term graduate courses for students enrolled in a two-year program. In order to maintain the minimum average of High Pass, each grade of Pass on the student’s transcript must be balanced by one grade of Honors. Each grade of Fail must be balanced by two grades of Honors. If a student retakes a course in which the student has received a failing grade, only the newer grade will be considered in calculating this average. The initial grade of Fail, however, will remain on the student’s transcript. A grade awarded at the conclusion of a full-year course in which no grade is awarded at the end of the first term would be counted twice in calculating this average.

**Curriculum**

**Required Courses**

BIS 550	Topics in Biomedical Informatics and Data Science	1
BIS 560	Introduction to Health Informatics	1
BIS 562	Clinical Decision Support	1
or BIS 640	User-Centered Design of Digital Health Tools	
BIS 633	Population and Public Health Informatics	1
BIS 634	Computational Methods for Informatics	1
BIS 638	Clinical Database Management Systems and Ontologies	1
BIS 685	Capstone in Health Informatics	1
BIS 686	Capstone in Health Informatics	1
EPH 508	Foundations of Epidemiology and Public Health	1
or EPH 509	Fundamentals of Epidemiology	
EPH 608	Frontiers of Public Health <sup>1</sup>	1

<sup>1</sup> Students entering the program with an M.P.H. or relevant graduate degree may be exempt.

**MS Suggested Electives in Informatics, Statistics and Data Science (4 course units)**

BIS 540	Fundamentals of Clinical Trials	1
BIS 567	Bayesian Statistics	1
BIS 568	Applied Artificial Intelligence in Healthcare	1
BIS 620	Data Science Software Systems	1

BIS 621	Regression Models for Public Health	1
BIS 623	Advanced Regression Models	1
BIS 628	Longitudinal and Multilevel Data Analysis	1
BIS 630	Applied Survival Analysis	1
BIS 645	Statistical Methods in Human Genetics	1
BIS 662	Computational Statistics	1
BIS 691	Theory of Generalized Linear Models	1
BIS 692	Statistical Methods in Computational Biology	1
CB&B 555	Unsupervised Learning for Big Data	1
CB&B 567	Topics in Deep Learning: Methods and Biomedical Applications	1
CB&B 645	Statistical Methods in Computational Biology	1
CB&B 663	Deep Learning Theory and Applications	1
CDE 534	Applied Analytic Methods in Epidemiology	1
CPSC 540	Database Design and Implementation	1
CDE 566	Causal Inference Methods in Public Health Research	1
CPSC 546	Data and Information Visualization	1
CPSC 564	Algorithms and their Societal Implications	1
CPSC 577	Natural Language Processing	1
CPSC 581	Introduction to Machine Learning	1
CPSC 582	Current Topics in Applied Machine Learning	1
CPSC 583	Deep Learning on Graph-Structured Data	1
CPSC 670	Topics in Natural Language Processing	1
EMD 533	Implementation Science	1
EMD 553	Transmission Dynamic Models for Understanding Infectious Diseases	1
ENAS 529		0
ENAS 544	Fundamentals of Medical Imaging	1
HPM 559	Big Data, Privacy, and Public Health Ethics	1
EPH 510	Health Policy and Health Care Systems	1
HPM 560	Health Economics and U.S. Health Policy	1
HPM 570	Cost-Effectiveness Analysis and Decision-Making	1
HPM 573	Advanced Topics in Modeling Health Care Decisions	1
IMED 625	Principles of Clinical Research	1
INP 560	R Stats for Neuroscience	1
MGT 525	Competitive Strategy <sup>1</sup>	4
MGT 534	Personal Leadership <sup>1</sup>	4
MGT 612	Introduction to Social Entrepreneurship	4
MGT 656	Management of Software Development <sup>1</sup>	4
S&DS 517	Applied Machine Learning and Causal Inference	1
S&DS 530	Data Exploration and Analysis	1

S&DS 562	Computational Tools for Data Science	1
S&DS 563	Multivariate Statistical Methods for the Social Sciences	1
S&DS 565	Introductory Machine Learning	1
S&DS 583	Time Series with R/Python	1
S&DS 610	Statistical Inference	1
S&DS 663	Computational Mathematics Situational Awareness and Survival Skills <sup>1</sup>	1
S&DS 664	Information Theory	1

<sup>1</sup> These courses are offered in the School of Management.

In addition, in the second year of the program, students are required to complete an independent capstone project (BIS 685/BIS 686) under the direction of a faculty member. This project may fall into one of the main areas—clinical informatics; clinical research informatics; population health informatics; and implementation of new methods and technology—and may include elements from several of these areas. Students are required to prepare a carefully written report and make an oral presentation of the work to the faculty and students. A capstone committee consisting of two faculty members and one outside reader will provide guidance to the candidate as to the suitability of the project and will monitor its progress.

### Competencies

Upon receiving an M.S. in the health informatics concentration of public health, the student will be able to:

- Select informatics methods appropriate for a given public health context.
- Compare the health information system structure and function across regional, national, and international settings.
- Assess population informatics needs, assets, and capacities that affect communities' health.
- Propose strategies to identify stakeholders and build coalitions and partnerships for influencing public health informatics.
- Communicate audience-appropriate public health content, both in writing and through oral presentation.
- Apply systems thinking tools to a public health informatics issue.

Ph.D. or terminal M.S. degree program materials are available upon request to the Office of the Director of Graduate Studies (c/o M. Elliot), School of Public Health, Yale University, PO Box 208034, New Haven CT 06520-8034; 203.785.6383; email, phdms.publichealth@yale.edu.

### REQUIRED COURSES

For a complete list of Public Health courses, see the School of Public Health bulletin, available online at <https://bulletin.yale.edu>; and Yale Course Search at <https://courses.yale.edu>.

All Ph.D. students are required to take the following courses. Students entering the program with an M.P.H. may be exempt from EPH 608.

EPH 600 Research Ethics and Responsibility

EPH 608 Frontiers of Public Health