

# Twin Cities Campus

Health Informatics Ph.D. Health Informatics, AHC Inst

Graduate School

Link to a list of faculty for this program.

## Contact Information: Physical Address: 8-100 PWB, 516 Delaware St. SE, Minneapolis, MN 55455 Mailing Address: MMC 912, 420 Delaware St. SE, Minneapolis, MN 55455 Email: <u>ihi@umn.edu</u>

Website: http://healthinformatics.umn.edu

- Program Type: Doctorate
- Requirements for this program are current for Fall 2020
- Length of program in credits: 70
- This program does not require summer semesters for timely completion.
- Degree: Doctor of Philosophy

Along with the program-specific requirements listed below, please read the <u>General Information</u> section of the catalog website for requirements that apply to all major fields.

Health informatics (also known as biomedical informatics) is an interdisciplinary field of scholarship that applies computer, information, statistical, management, and related scientific methods to enable biomedical discovery and support the effective and efficient use and analysis of data, management of information, and application of knowledge across the spectrum from basic science to clinical care. The ultimate goal of the field is to improve the health, well-being, and economic functioning of society. Students take a sequence of core courses in health informatics, computing, and biostatistics, and electives in technical and health science areas, and pursue one of four tracks: data science and informatics for learning health systems; clinical informatics; translational bioinformatics; or precision and personalized medicine (PPM) informatics.

# **Program Delivery**

This program is available:

• via classroom (the majority of instruction is face-to-face)

# Prerequisites for Admission

The preferred undergraduate GPA for admittance to the program is 3.50.

Applicants must have a BS or equivalent in science, technology, engineering, computer science, math, or another pertinent field from a regionally accredited university or international equivalent.

#### **Required prerequisites**

#### **Health or Biological Sciences**

Applicants must have taken 6 semester-credits or 9 quarter-credits at the undergraduate or graduate level in medical, life, or biological sciences from a regionally accredited institution of higher learning or equivalent. This broadly defined requirement includes most courses with a health or biology emphasis, including biostatistics, health services research, and public health, as well as more traditional biology or life science courses.

6-9 credits

# Computer Science

# **Clinical Informatics Track**

Documented work or educational experience working with a general purpose programming language such as C, C++, Java, Visual Basic, PASCAL, etc.

or HINF 5502 - Python Programming Essentials for the Health Sciences (1.0 cr)

#### or Other Tracks

Applicants to the data science for learning health systems, translational bioinformatics, and precision and personalized medicine informatics tracks must also have taken an introduction to data structures and algorithms, such as the course listed below. CSCI 1933 - Introduction to Algorithms and Data Structures (4.0 cr)

# **Track-Specific Prerequisites**

Applicants to the data science for learning health systems, translational bioinformatics, and precision and personalized medicine informatics tracks must also have the following prerequisites or must take remedial courses at the discretion of the admissions committee:



# UNIVERSITY OF MINNESOTA Driven to Discover

#### Mathematics

Applicants must have college-level calculus and linear algebra, such as the courses listed below. MATH 1271 - Calculus I [MATH] (4.0 cr) CSCI 2033 - Elementary Computational Linear Algebra (4.0 cr)

or MATH 4242 - Applied Linear Algebra (4.0 cl

- Statistics
- Applicants must have college-level statistics, such as the courses below.
- STAT 3011 Introduction to Statistical Analysis [MATH] (4.0 cr)
- or STAT 3021 Introduction to Probability and Statistics (3.0 cr)

Applicants must submit their test score(s) from the following:

- GRE
- General Test Verbal Reasoning: 151
- General Test Quantitative Reasoning: 160
- General Test Analytical Writing: 4

International applicants must submit score(s) from one of the following tests:

- TOEFL
- Internet Based Total Score: 79
- Internet Based Writing Score: 21
- Internet Based Reading Score: 19
- IELTS
- Total Score: 6.5
- Reading Score: 6.5
- Writing Score: 6.5
- MELAB
- Final score: 80

The preferred English language test is Test of English as Foreign Language

Key to test abbreviations(GRE, TOEFL, IELTS, MELAB).

For an online application or for more information about graduate education admissions, see the <u>General Information</u> section of the catalog website.

# Program Requirements

46 credits are required in the major. 24 thesis credits are required.

This program may be completed with a minor.

Use of 4xxx courses toward program requirements is permitted under certain conditions with adviser approval.

A minimum GPA of 3.00 is required for students to remain in good standing.

At least 2 semesters must be completed before filing a Degree Program Form.

All courses taken, milestones met, and progress made in the program are subject to Academic Program Committee (APC) review. The inclusion of 4000-level coursework requires APC approval.

#### Required Core Coursework (14 credits)

Phase I (12 credits)

Take the following courses. Take HINF 5436 twice for a total of 2 credits.

- HINF 5430 Foundations of Health Informatics I (3.0 cr)
- HINF 8430 Foundations of Health Informatics I Lab (2.0 cr)
- HINF 5436 AHC Informatics Grand Rounds (1.0 cr)
- HINF 5440 Foundations of Translational Bioinformatics (3.0 cr)
- HINF 8440 Foundations of Translational Bioinformatics Lab (2.0 cr)
- Phase II (2 credits)

Take the following course, with APC approval, after completing Phase I coursework.

HINF 8525 - Health Informatics Teaching (2.0 cr)

# Thesis Credits

Take at least 24 doctoral thesis credits in consultation with the APC.



HINF 8888 - Thesis Credit: Doctoral (1.0 - 24.0 cr)

# **Program Sub-plans**

Students are required to complete one of the following sub-plans. Students may not complete the program with more than one sub-plan.

# **Clinical Informatics**

The clinical informatics track provides instruction and training for students interested in clinical applications methods and applications. The curriculum includes instruction in health data and coding, systems analysis, human-computer interaction, current informatics research, and current applications such as decision support systems, natural language processing, and predictive modeling. Additionally, students learn biostatistical methods, relational database theory and practice, analytics and data science methodologies, consumer health informatics, and interprofessional practice. Electives supplement individual student interests in areas such as computer programming, health data management, health care finance, and public and population health (with scope to include personempowered participation and inter-professional engagement). Courses use a mixture of theoretical and applied subject matter to provide a solid grounding in current informatics thinking and practice.

## **Clinical Informatics Coursework (32 credits)**

## Core Coursework (16 credits)

Take the following core courses: HINF 5431 - Foundations of Health Informatics II (3.0 cr) HINF 8431 - Foundations of Health Informatics II Lab (2.0 cr) HINF 5510 - Applied Health Care Databases: Database Principles and Data Evaluation (3.0 cr) HINF 5520 - Informatics Methods for Health Care Quality, Outcomes, and Patient Safety (2.0 cr) HINF 5531 - Health Data Analytics and Data Science (3.0 cr) NURS 5116 - Consumer Health Informatics (2.0 cr) NURS 7108 - Population Health Informatics (2.0 cr) **Required Biostatistics Coursework (8 credits)** Take the following two courses: PUBH 6450 - Biostatistics I (4.0 cr) PUBH 6451 - Biostatistics II (4.0 cr) Electives Select at least 8 elective credits, in consultation with the APC, to complete the 46 course credits required for the PhD degree. BIOC 5361 - Microbial Genomics and Bioinformatics (3.0 cr) BIOC 8007 - Molecular Biology of the Genome (2.0 cr) BIOC 8008 - Molecular Biology of the Transcriptome (2.0 cr) CGSC 8410 - Perspectives in Learning, Perception, and Cognition (2.0 cr) CSCI 5106 - Programming Languages (3.0 cr) CSCI 5115 - User Interface Design, Implementation and Evaluation (3.0 cr) CSCI 5271 - Introduction to Computer Security (3.0 cr) CSCI 5421 - Advanced Algorithms and Data Structures (3.0 cr) CSCI 5461 - Functional Genomics, Systems Biology, and Bioinformatics (3.0 cr) CSCI 5481 - Computational Techniques for Genomics (3.0 cr) CSCI 5511 - Artificial Intelligence I (3.0 cr) CSCI 5521 - Machine Learning Fundamentals (3.0 cr) CSCI 5525 - Machine Learning: Analysis and Methods (3.0 cr) CSCI 5607 - Fundamentals of Computer Graphics 1 (3.0 cr) CSCI 5608 - Fundamentals of Computer Graphics II (3.0 cr) CSCI 5707 - Principles of Database Systems (3.0 cr) CSCI 5708 - Architecture and Implementation of Database Management Systems (3.0 cr) CSCI 5801 - Software Engineering I (3.0 cr) CSCI 8725 - Databases for Bioinformatics (3.0 cr) DES 5185 - Human Factors in Design (3.0 cr) EPSY 5244 - Survey Design, Sampling, and Implementation (3.0 cr) EPSY 5262 - Intermediate Statistical Methods (3.0 cr) EPSY 5621 {Inactive}(3.0 cr) GCD 8103 - Human Histology (5.0 cr) HINF 5450 - Foundations of Precision Medicine Informatics (3.0 cr) HINF 5494 - Topics in Health Informatics (1.0 - 3.0 cr) HINF 5496 - Internship in Health Informatics (1.0 - 6.0 cr) HINF 5502 - Python Programming Essentials for the Health Sciences (1.0 cr) HINF 5610 - Foundations of Biomedical Natural Language Processing (3.0 cr) HINF 5620 - Data Visualization for the Health Sciences (3.0 cr) HINF 5630 - Clinical Data Mining (3.0 cr) HINF 5640 - Advanced Translational Bioinformatics Methods (3.0 cr)

© 2005 by the Regents of the University of Minnesota

The University of Minnesota is an equal opportunity educator and employer.

Information current as of February 24, 2024



HINF 5650 - Integrative Genomics and Computational Methods (3.0 cr) HINF 8220 - Computational Causal Analytics (3.0 cr) HINF 8405 - Advanced Topics in Health Informatics I (1.0 - 4.0 cr) HINF 8406 - Advanced Topics in Health Informatics II (1.0 - 4.0 cr) HINF 8492 - Advanced Readings or Research in Health Informatics (1.0 - 6.0 cr) HINF 8535 - Advanced Health Informatics Research Methods (3.0 cr) IDSC 6041 - Information Technology Management (2.0 cr) IDSC 6051 - Information Technologies and Solutions (2.0 cr) IDSC 6471 - Knowledge Management (2.0 cr) IDSC 8721 - Behavioral Decision Theory (3.0 cr) IE 8521 - Optimization (4.0 cr) IE 8531 - Discrete Optimization (4.0 cr) KIN 5001 - Foundations of Human Factors/Ergonomics (3.0 cr) LING 5001 - Introduction to Linguistics (4.0 cr) LING 5205 - Semantics (3.0 cr) LING 5801 - Introduction to Computational Linguistics (3.0 cr) MATH 5445 - Mathematical Analysis of Biological Networks (4.0 cr) MATH 5467 - Introduction to the Mathematics of Image and Data Analysis (4.0 cr) MATH 5652 - Introduction to Stochastic Processes (4.0 cr) MEDC 5245 - Introduction to Drug Design (3.0 cr) MILI 6992 - Healthcare Delivery Innovations:Optimizing Cost and Quality (2.0 cr) MILI 6995 - Medical Industry Valuation Laboratory (2.0 cr) NURS 5115 - Nursing Informatics and Digital Health Technologies (3.0 cr) NURS 5117 - Consumer Health Informatics Practicum (2.0 cr) NURS 6105 - Systems Analysis and Design (3.0 cr) NURS 7106 - Knowledge Representation and Interoperability Practicum (2.0 cr) NURS 7109 - Population Health Informatics Practicum (2.0 cr) NURS 7113 - Clinical Decision Support: Theory (2.0 cr) NURS 7114 - Clinical Decision Support Practicum (2.0 cr) NURS 7118 - Human Factors and Human-Computer Interaction in Health Informatics (3.0 cr) NURS 7610 - Nurses Leading Change and Innovation to Transform Healthcare (3.0 cr) PHAR 6224 - Advanced Pharmacogenomics and Precision Medicine (2.0 cr) PUBH 6020 - Fundamentals of Social and Behavioral Science (2.0 cr) PUBH 6102 - Issues in Environmental Health (2.0 cr) PUBH 6131 - Working in Global Health (2.0 cr) PUBH 6320 - Fundamentals of Epidemiology (3.0 cr) PUBH 6325 - Data Processing with PC-SAS (1.0 cr) PUBH 6341 - Epidemiologic Methods I (3.0 cr) PUBH 6386 - Cardiovascular Disease Epidemiology and Prevention (2.0 cr) PUBH 6420 - Introduction to SAS Programming (1.0 cr) PUBH 6541 - Statistics for Health Management Decision Making (3.0 cr) PUBH 6555 - Health Economics (2.0 cr) PUBH 6556 - Health and Health Systems (3.0 cr) PUBH 6557 - Health Finance I (3.0 cr) PUBH 6558 - Health Finance II (3.0 cr) PUBH 6560 - Operations Research and Quality in Health Care (3.0 cr) PUBH 6562 - Information Technology in Health Care (2.0 cr) PUBH 6564 - Private Purchasers of Health Care: Roles of Employers and Health Plans in U.S. Health Care System (2.0 cr) PUBH 6565 - Innovation of Healthcare Services (2.0 cr) PUBH 6717 - Decision Analysis for Health Care (2.0 cr) PUBH 6724 - The Health Care System and Public Health (3.0 cr) PUBH 6742 - Ethics in Public Health: Research and Policy (1.0 cr) PUBH 6751 - Principles of Management in Health Services Organizations (2.0 cr) PUBH 6765 - Continuous Quality Improvement: Methods and Techniques (3.0 cr) PUBH 6780 - Topics in Public Health Administration and Policy (1.0 - 3.0 cr) PUBH 6800 - Topics: Health Services Research and Policy (0.5 - 4.0 cr) PUBH 6802 {Inactive}(3.0 cr) PUBH 6803 - Conducting a Systematic Literature Review (3.0 cr) PUBH 6809 - Advanced Methods in Health Decision Science (3.0 cr) PUBH 6814 {Inactive}(2.0 cr) PUBH 6832 - Economics of the Health Care System (3.0 cr) PUBH 6862 - Cost-Effectiveness Analysis in Health Care (3.0 cr) PUBH 6863 - Understanding Health Care Quality (2.0 cr) PUBH 7400 - Topics: Biostatistics (0.5 - 4.0 cr) PUBH 7401 - Fundamentals of Biostatistical Inference (4.0 cr) PUBH 7402 - Biostatistics Modeling and Methods (4.0 cr)

© 2005 by the Regents of the University of Minnesota

The University of Minnesota is an equal opportunity educator and employer.



PUBH 7405 - Biostatistical Inference I (4.0 cr)
PUBH 7407 - Analysis of Categorical Data (3.0 cr)
PUBH 7415 - Introduction to Clinical Trials (3.0 cr)
PUBH 7420 - Clinical Trials: Design, Implementation, and Analysis (3.0 cr)
PUBH 7430 - Statistical Methods for Correlated Data (3.0 cr)
PUBH 7440 - Introduction to Bayesian Analysis (3.0 cr)
PUBH 7445 - Statistics for Human Genetics and Molecular Biology (3.0 cr)
PUBH 7460 - Advanced Statistical Computing (3.0 cr)
PUBH 7475 - Statistical Learning and Data Mining (3.0 cr)
PUBH 7588 - Information Uses in Long-Term Care (2.0 cr)
PUBH 8432 - Probability Models for Biostatistics (3.0 cr)
PUBH 8442 - Bayesian Decision Theory and Data Analysis (3.0 cr)
PUBH 8445 - Statistics for Human Genetics and Molecular Biology (3.0 cr)
PUBH 8446 - Advanced Statistical Genetics and Genomics (3.0 cr)
PUBH 8452 - Advanced Longitudinal Data Analysis (3.0 cr)
PUBH 8462 - Advanced Survival Analysis (3.0 cr)
PUBH 8472 - Spatial Biostatistics (3.0 cr)
PUBH 8801 - Health Services Policy Analysis: Theory (1.0 cr)
PUBH 8810 - Research Studies in Health Care (3.0 cr)
STAT 5101 - Theory of Statistics I (4.0 cr)
STAT 5302 - Applied Regression Analysis (4.0 cr)
STAT 5303 - Designing Experiments (4.0 cr)
STAT 5401 - Applied Multivariate Methods (3.0 cr)
STAT 5511 - Time Series Analysis (3.0 cr)
STAT 8051 - Advanced Regression Techniques: linear, nonlinear and nonparametric methods (3.0 cr)
STAT 8052 - Applied Statistical Methods 2: Design of Experiments and Mixed -Effects Modeling (3.0 cr)
STAT 8053 - Applied Statistical Methods 3: Multivariate Analysis and Advanced Regression (3.0 cr)

#### Data Science and Informatics for Learning Health Systems

The data science and informatics for learning health systems track builds on the highly regarded data science program offered jointly by the School of Engineering, School of Public Health, and School of Statistics. It also takes advantage of the School of Nursing's breadth of nursing and health informatics courses.

Students who pursue the data science and informatics for learning health systems track are expected to earn the Universitys data science MS degree en route to completing the PhD.

Students must consult with the APC to coordinate completion of coursework and other requirements for the data science MS, the health informatics PhD, and the data science and informatics for learning health systems track. Credits earned in the Universitys data science MS program may be used to fulfill required courses or elective credits in the data science and informatics for learning health systems track, subject to APC approval. Students who have an MS in data science from a comparable program may be exempt from this requirement in whole or in part, subject to APC review and approval.

#### Data Science and Informatics Coursework (32 credits)

#### Core Coursework (18 credits)

Take the following courses, in consultation with the APC, after completion of the data science MS degree. Take HINF 5496 and HINF 8492 for at least 3 credits each.

HINF 5496 - Internship in Health Informatics (1.0 - 6.0 cr)

HINF 5510 - Applied Health Care Databases: Database Principles and Data Evaluation (3.0 cr)

HINF 5630 - Clinical Data Mining (3.0 cr)

HINF 8220 - Computational Causal Analytics (3.0 cr)

HINF 8492 - Advanced Readings or Research in Health Informatics (1.0 - 6.0 cr)

## Elective Coursework (14 credits)

Select at least 14 elective credits from the following list, in consultation with the APC, to complete the 46 course credits required for the PhD degree. Credits earned in pursuit of the data science MS may be used to fulfill elective course requirements for this track, subject to APC approval.

Take 14 or more course(s) from the following:

# Informatics

Take 0 or more course(s) from the following:

•HINF 5431 - Foundations of Health Informatics II (3.0 cr)

- •HINF 8431 Foundations of Health Informatics II Lab (2.0 cr)
- •HINF 5610 Foundations of Biomedical Natural Language Processing (3.0 cr)
- •HINF 5620 Data Visualization for the Health Sciences (3.0 cr)
- •MATH 5467 Introduction to the Mathematics of Image and Data Analysis (4.0 cr)

## Applications

Take 0 or more course(s) from the following:

•NURS 7113 - Clinical Decision Support: Theory (2.0 cr)

© 2005 by the Regents of the University of Minnesota

The University of Minnesota is an equal opportunity educator and employer.

Information current as of February 24, 2024



UNIVERSITY OF MINNESOTA Driven to Discover™

 PUBH 6102 - Issues in Environmental Health (2.0 cr) •PUBH 6560 - Operations Research and Quality in Health Care (3.0 cr) •PUBH 6717 - Decision Analysis for Health Care (2.0 cr) PUBH 6751 - Principles of Management in Health Services Organizations (2.0 cr) PUBH 6765 - Continuous Quality Improvement: Methods and Techniques (3.0 cr) •PUBH 6809 - Advanced Methods in Health Decision Science (3.0 cr) •PUBH 6814 {Inactive}(2.0 cr) •PUBH 6862 - Cost-Effectiveness Analysis in Health Care (3.0 cr) Advanced Methodology Take 0 or more course(s) from the following: PUBH 6341 - Epidemiologic Methods I (3.0 cr) •PUBH 8452 - Advanced Longitudinal Data Analysis (3.0 cr) •PUBH 8462 - Advanced Survival Analysis (3.0 cr) PUBH 8472 - Spatial Biostatistics (3.0 cr) Data Science Take 0 or more course(s) from the following: •STAT 5101 - Theory of Statistics I (4.0 cr) •STAT 5102 - Theory of Statistics II (4.0 cr) •STAT 5302 - Applied Regression Analysis (4.0 cr) STAT 5511 - Time Series Analysis (3.0 cr) •STAT 5401 - Applied Multivariate Methods (3.0 cr) STAT 8051 - Advanced Regression Techniques: linear, nonlinear and nonparametric methods (3.0 cr) •PUBH 7440 - Introduction to Bayesian Analysis (3.0 cr) •CSCI 5521 - Machine Learning Fundamentals (3.0 cr) CSCI 5523 - Introduction to Data Mining (3.0 cr) •CSCI 5525 - Machine Learning: Analysis and Methods (3.0 cr) •PUBH 8475 - Statistical Learning and Data Mining (3.0 cr)

•CSCI 5105 - Introduction to Distributed Systems (3.0 cr)

•CSCI 5451 - Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3.0 cr)

•CSCI 5707 - Principles of Database Systems (3.0 cr)

#### **Translational Bioinformatics**

The translational bioinformatics track bridges genomics and bioinformatics to precision medicine through its methods and techniques development and innovation that directly relate to the study of basic biological science and diseases. The computational methods related to genomics, epigenomics, transcriptomics, proteomics, metabolomics, and pharmacogenomcis are included, which build the connection of molecular findings and phenotypes to characterize disease susceptibility or determine disease markers, and predict response to treatment and prognosis. The program offers three specialized areas: structural and functional genomics, microbiomics and metagenomics, and cancer genomics.

Students must consult with the APC to coordinate completion of coursework and other requirements.

#### **Translational Bioinformatics Coursework (32 credits)**

#### Phase 1 (22 credits)

Take the following courses for a total of 22 credits:

CSCI 5521 - Machine Learning Fundamentals (3.0 cr)

CSCI 5421 - Advanced Algorithms and Data Structures (3.0 cr)

HINF 8220 - Computational Causal Analytics (3.0 cr)

HINF 5650 - Integrative Genomics and Computational Methods (3.0 cr)

STAT 8051 - Advanced Regression Techniques: linear, nonlinear and nonparametric methods (3.0 cr)

STAT 8052 - Applied Statistical Methods 2: Design of Experiments and Mixed -Effects Modeling (3.0 cr)

BIOC 8007 - Molecular Biology of the Genome (2.0 cr)

BIOC 8008 - Molecular Biology of the Transcriptome (2.0 cr)

#### Phase II (6 credits)

Take the following courses after competing Phase I, and with the approval of the APC:

HINF 5496 - Internship in Health Informatics (1.0 - 6.0 cr)

HINF 8492 - Advanced Readings or Research in Health Informatics (1.0 - 6.0 cr)

## Elective Coursework (4 credits)

Select at least 4 elective credits from the following list, in consultation with the APC, to complete the 46 course credits required for the PhD degree.

HINF 5431 - Foundations of Health Informatics II (3.0 cr)

HINF 8431 - Foundations of Health Informatics II Lab (2.0 cr)

HINF 5450 - Foundations of Precision Medicine Informatics (3.0 cr)

HINF 5610 - Foundations of Biomedical Natural Language Processing (3.0 cr)

MEDC 5245 - Introduction to Drug Design (3.0 cr)

PHAR 6224 - Advanced Pharmacogenomics and Precision Medicine (2.0 cr)

PUBH 7415 - Introduction to Clinical Trials (3.0 cr)

© 2005 by the Regents of the University of Minnesota

The University of Minnesota is an equal opportunity educator and employer.

Information current as of February 24, 2024



# UNIVERSITY OF MINNESOTA

PUBH 7420 - Clinical Trials: Design, Implementation, and Analysis (3.0 cr) PUBH 8445 - Statistics for Human Genetics and Molecular Biology (3.0 cr) STAT 8053 - Applied Statistical Methods 3: Multivariate Analysis and Advanced Regression (3.0 cr) Precision and Personalized Medicine Informatics The precision and personalized medicine informatics track provides a didactic program for students training in informatics who will develop specialized knowledge in precision informatics methods applied to personal and population health-focused problems. The scope of this track includes social determinants of health and inter-professional research and expertise. Students will develop skills in quantitative methods and biomedical sciences for their application to precision medicine. In addition, students will gain an understanding of medical and biological science to provide needed context on which to apply informatics methods. Students must consult with the APC to coordinate completion of coursework and other requirements. Precision and Personalized Medicine Informatics Coursework (32 credits) Phase I (19 credits) Take the following courses: HINF 5450 - Foundations of Precision Medicine Informatics (3.0 cr) HINF 5510 - Applied Health Care Databases: Database Principles and Data Evaluation (3.0 cr) HINF 5520 - Informatics Methods for Health Care Quality, Outcomes, and Patient Safety (2.0 cr) PUBH 7401 - Fundamentals of Biostatistical Inference (4.0 cr) PUBH 7402 - Biostatistics Modeling and Methods (4.0 cr) HINF 5531 - Health Data Analytics and Data Science (3.0 cr) or HINF 5630 - Clinical Data Mining (3.0 cr) Phase II (8 credits) Take the following courses after completing Phase I, and with the approval of the APC. Take HINF 5496 and HINF 8492 for at least 3 credits each. HINF 5496 - Internship in Health Informatics (1.0 - 6.0 cr) HINF 8492 - Advanced Readings or Research in Health Informatics (1.0 - 6.0 cr) PHAR 6224 - Advanced Pharmacogenomics and Precision Medicine (2.0 cr)

#### **Elective Coursework (5 credits)**

Select at least 5 elective credits, in consultation with the APC, to complete the 46 course credits required for the PhD degree.

HINF 5431 - Foundations of Health Informatics II (3.0 cr)

MATH 5652 - Introduction to Stochastic Processes (4.0 cr)

MATH 5445 - Mathematical Analysis of Biological Networks (4.0 cr)

PUBH 7430 - Statistical Methods for Correlated Data (3.0 cr)

PUBH 7440 - Introduction to Bayesian Analysis (3.0 cr)

PUBH 7445 - Statistics for Human Genetics and Molecular Biology (3.0 cr)

PUBH 8432 - Probability Models for Biostatistics (3.0 cr)

PUBH 8442 - Bayesian Decision Theory and Data Analysis (3.0 cr)

- PUBH 8445 Statistics for Human Genetics and Molecular Biology (3.0 cr)
- PUBH 8446 Advanced Statistical Genetics and Genomics (3.0 cr)
- STAT 5511 Time Series Analysis (3.0 cr)
- STAT 5401 Applied Multivariate Methods (3.0 cr)