BIOMEDICAL AND HEALTH INFORMATICS, PHD

The PhD in Biomedical and Health Informatics is an interdisciplinary doctoral program offered by UWM through collaboration between several academic units at UWM and the Medical College of Wisconsin. The Program is housed in the UWM Department of Electrical Engineering and Computer Science. It is guided by a Steering Committee consisting of faculty from the academic units participating in the Program.

Biomedical and health informatics is a field that is concerned with the cognitive, information processing, and communication aspects of medicine and healthcare including the information sciences and technology to support these tasks. The field covers the application of information technology in clinical medicine, medical record keeping, medical instrumentation, and healthcare management.

The main goal of the PhD program is to prepare graduates to perform advanced research in the discipline and to assume leadership roles in medical and healthcare industries. The degree is philosophically conceptualized as involving several disciplines in a collaborative learning process with the goal of fostering inter-professional interactions and inquiry. This degree will build upon existing graduate programs and research in the participating units. Qualified students with strong academic records in any of these programs will be considered for admission.

Other participating units:
- College of Health Sciences
- College of Nursing
- Lubar School of Business
- School of Information Studies
- Zilber School of Public Health
- The Medical College of Wisconsin

Requirements
Admission Requirements
Application Deadlines
Application deadlines vary by program, please review the application deadline chart (http://uwm.edu/graduateschool/program-deadlines/) for specific programs. Other important dates and deadlines can be found by using the One Stop calendars (https://uwm.edu/onestop/dates-and-deadlines/).

Admission
An applicant must meet the UWM Graduate School requirements as well as the following to be considered for admission to the program:

Master’s degree in biomedical and health informatics or a related area such as Computer Science, Electrical Engineering, Health Sciences, Business Administration, Nursing, or an MD degree. Exceptionally strong candidates with Bachelor's degree in a related area will also be considered for admission.

1. At least two letters of recommendation that attest to academic and/or professional qualifications.
2. Scores from the GRE (general) or GMAT or MCAT (test taken within the last five years.)

For applicants who intend to satisfy the English proficiency requirement by submission of test scores, a score of at least 79 on the computer-based Test of English as a Foreign Language (TOEFL) IBT is required. A score of 6.5 on the international English Language Testing Systems (IELTS) examination will be required in lieu of the TOEFL.

Requests for financial support must also be submitted below:
- Co Director
  Biomedical and Health Informatics Program
  College of Engineering and Applied Science
  University of Wisconsin-Milwaukee
  Milwaukee, WI 53201

Areas of Concentration
The PhD program requires a student to follow one of the following six areas of concentration. (At the time of application, each applicant should indicate a preferred area of concentration in their statement of Reasons for Graduate Study.)

Translational Bioinformatics Track
The track in Translational Bioinformatics centers on driving the flow of knowledge from "bench to bedside", bridging the gap between basic and clinical informatics research. This discipline has applications to drug development, genetics research, and the use of animal models to develop new understandings or treatments, which has implications both to basic science and to commercialization.

Knowledge Based Systems Track
The Knowledge Based Systems track is designed to train students in the development of techniques to support decision-making in medical practice (including both clinical and administrative decision-making) and customized instruction on health and medical topics for patients and health care providers. Technical areas include decision analysis, expected utility theory and cost-effectiveness analysis, computer-based decision support systems, user modeling and user interface design, intelligent tutoring systems, knowledge representation, structured reporting, and data mining and knowledge discovery.

Health Services Management & Policy Track
Health services management and policy research is broad in scope and touches on all of the standard functional business areas (e.g., management, strategy and marketing, finance/economics, management information systems, human resources management) in addition to government health policy/reimbursement/regulation, insurance and other payer mechanisms, dealing with health professionals, and illness/health in individuals and in populations. The track is designed to equip students to deal with both management information and with population health and illness information and research to understand the implications of such information and research, and to transform inferences from that information and research into practical recommendations on the national, state, and local level. By its nature, it is applied to health services settings including hospitals, skilled-nursing facilities, medical group practices, public health agencies, mental health services, managed care organizations, and integrated health networks.

Health Information Systems Track
The track in Health Information Systems is designed to explore the role of administrative and clinical information systems in health care organizations. Attention will be directed at the design, implementation, and maintenance of the broad array of computer applications used in the health care industry. An interdisciplinary approach will be taken drawing on expertise from the health professions, management information systems, and library and information science. Curricular content
will range from systems analysis and design, system efficacy and management, to e-commerce.

**Medical Imaging and Instrumentation Track**
The track in Medical Imaging and Instrumentation is designed to train students in understanding and developing medical imaging systems and medical electronic instrumentation. The aspects emphasized in this track are medical imaging systems, image processing, computer vision, pattern recognition, medical instrumentation development and optimization, computer modeling, applications of electric and magnetic fields, and wireless communication.

**Public Health Informatics Track**
The Public Health Informatics track is designed to train students in the development of techniques, methods and tools to conduct public health research and to provide public health programs and tools for practical use. Graduates of this track will also be able to provide customized instruction on public health and related biomedical topics for public health workers, the public and others such as those in public health policy who will benefit from public health informatics. Technical areas include databases, tools and techniques for acquiring, processing, warehousing, and analyzing public health data. Other areas of expertise include utility theory and cost-effectiveness analysis, computer-based decision support systems, user modeling and user interface design, intelligent tutoring systems, structured reporting, and data mining.

**Credits and Courses**
Students enrolled in this program must follow all UWM Graduate School requirements and regulations. The minimum requirement for the Ph.D. in Biomedical and Health Informatics will be 58-63 credits beyond the bachelor’s degree. Up to 24 credits from a related master’s degree may be applied toward the Ph.D.

The curriculum will consist of a common set of core courses for all tracks, required and elective courses for each individual track, and the dissertation. The purpose of the core is to ensure that all graduates of the program share a basic common knowledge in biomedical and health informatics. The purpose of the tracks is to enable the students to develop significant strengths in specific sub-areas within biomedical and health informatics. The courses identified in the curriculum are offered by UWM or MCW and, in some case, by both institutions. Following are descriptions of these components and their corresponding credit requirements.

**Core Courses**
The core courses provide a comprehensive structure for the foundations needed for all students in biomedical and health informatics irrespective of their special interests. This includes a series of seminars that deal with different aspects of biomedical and health informatics. All students must take the following core courses or must have taken equivalent courses in previous study.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCW 13200(A,B)</td>
<td>Medical Informatics, 6 quarter cr</td>
<td>2</td>
</tr>
<tr>
<td>HCA 700</td>
<td>Introduction to Health Care Informatics</td>
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</tr>
</tbody>
</table>

Select the following for four 1-credit semesters

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS 701</td>
<td>Human Pathophysiology I</td>
<td>3</td>
</tr>
<tr>
<td>HCA XXX</td>
<td>Physiology and Disease Informatics</td>
<td></td>
</tr>
</tbody>
</table>

**Track Electives**
The major advisor: Select 12 credits from the following (use course from program of major advisor):

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS ADM 997</td>
<td>Doctoral Dissertation</td>
<td></td>
</tr>
<tr>
<td>COMPSCI 998</td>
<td>Doctoral Thesis</td>
<td></td>
</tr>
<tr>
<td>ELECENG 998</td>
<td>Doctoral Thesis</td>
<td></td>
</tr>
<tr>
<td>HCA 890</td>
<td>Health Care Informatics Research and Thesis</td>
<td></td>
</tr>
<tr>
<td>INFOST 998</td>
<td>Doctoral Dissertation</td>
<td></td>
</tr>
<tr>
<td>NURS 997</td>
<td>Doctoral Dissertation</td>
<td></td>
</tr>
<tr>
<td>PH 990</td>
<td>Research and Dissertation</td>
<td></td>
</tr>
</tbody>
</table>

**Knowledge Based Systems Track**
The purpose of the MBA in Health Care Information Systems is to prepare students with the technical knowledge required to understand and handle the complex problems of organizing, processing and analyzing data in the health care setting.

**Required Mathematics & Quantitative Methods**

<table>
<thead>
<tr>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BUS ADM 795</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 995</td>
<td></td>
</tr>
<tr>
<td>ED PSY 624</td>
<td></td>
</tr>
<tr>
<td>IND ENS/OCTHPY 786</td>
<td></td>
</tr>
<tr>
<td>MTHSTAT 761</td>
<td></td>
</tr>
<tr>
<td>ECON 413</td>
<td>3</td>
</tr>
<tr>
<td>or MATH 771</td>
<td></td>
</tr>
</tbody>
</table>

**Track Electives**
The major advisor: Select 12-15 credits with approval of advisor and steering committee

<table>
<thead>
<tr>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS ADM 997</td>
<td></td>
</tr>
<tr>
<td>COMPSCI 998</td>
<td></td>
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<tr>
<td>ELECENG 998</td>
<td></td>
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<tr>
<td>HCA 890</td>
<td></td>
</tr>
<tr>
<td>INFOST 998</td>
<td></td>
</tr>
<tr>
<td>NURS 997</td>
<td></td>
</tr>
<tr>
<td>PH 990</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credits**

| Total Credits | 48-51 |

**Notes**
- Select the following for four 1-credit semesters
- Select one of the following
  - MCW 13200(A,B) Medical Informatics, 6 quarter cr
  - HCA 700 Introduction to Health Care Informatics
- Select one of the following
  - BMS 701 Human Pathophysiology I
  - HCA XXX Physiology and Disease Informatics
# Health Services Management & Policy Track

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS ADM 755</td>
<td>Health Care Administration and Delivery Systems</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 757</td>
<td>Managed Care and Integrated Health Networks</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 744</td>
<td>Information Technology Strategy and Management</td>
<td>3</td>
</tr>
<tr>
<td>BUSMGMT 720</td>
<td>Strategic Management in Health Care Organizations</td>
<td>3</td>
</tr>
<tr>
<td>BUSMGMT 727</td>
<td>Health Care Accounting, Law and Ethics</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 990</td>
<td>Doctoral Seminar in Strategic Management</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 996</td>
<td>Doctoral Seminar in Organizations:</td>
<td>3</td>
</tr>
</tbody>
</table>

## Required Mathematics & Quantitative Methods

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS ADM 918</td>
<td>Doctoral Seminar in Behavioral Research Methods in Management</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one of the following:

- BUS ADM 714 Multivariate Techniques in Management Research
- ECON 513 Introduction to Econometrics
- ED PSY 624 Educational Statistical Methods I
- ECON 710 Applied Econometrics

## Track Electives

Select 9 credits with approval of advisor and steering committee

## Dissertation

Select 12 credits from the following (use course from program of major advisor):

- BUS ADM 997 Doctoral Dissertation
- COMPSCI 998 Doctoral Thesis
- ELECENG 998 Doctoral Thesis
- HCA 890 Health Care Informatics Research and Thesis
- INFOS 998 Doctoral Dissertation
- NURS 997 Doctoral Dissertation
- PH 990 Research and Dissertation

Total Credits: 45

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# Health Information Systems Track

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS ADM 744</td>
<td>Information Technology Strategy and Management</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 747</td>
<td>Service-Oriented Analysis and Design</td>
<td>3</td>
</tr>
<tr>
<td>BUS ADM 817</td>
<td>Connected Systems for Business</td>
<td>3</td>
</tr>
<tr>
<td>or COMPSCI 759</td>
<td>Data Security</td>
<td>3</td>
</tr>
<tr>
<td>COMPSCI 720</td>
<td>Computational Models of Decision Making</td>
<td>3</td>
</tr>
<tr>
<td>HCA 721</td>
<td>Health Information Technology Procurement</td>
<td>3</td>
</tr>
<tr>
<td>HCA 723</td>
<td>Health Care Systems Applications - Administrative and</td>
<td>3</td>
</tr>
<tr>
<td>or HCA 760</td>
<td>Biomedical and Healthcare Terminology and Ontology</td>
<td>3</td>
</tr>
</tbody>
</table>

## Required

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECENG 436</td>
<td>Introduction to Medical Instrumentation</td>
<td>3</td>
</tr>
<tr>
<td>ELECENG 437</td>
<td>Introduction to Biomedical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>ELECENG 439</td>
<td>Introduction to Biomedical Optics</td>
<td>3</td>
</tr>
<tr>
<td>or ELECENG 712</td>
<td>Image Processing</td>
<td>3</td>
</tr>
<tr>
<td>ELECENG 737</td>
<td>Medical Imaging Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>ELECENG 765</td>
<td>Introduction to Fourier Optics and Optical Signal Processing</td>
<td>3</td>
</tr>
</tbody>
</table>

## Track Electives

Select 21 credits with approval of advisor and steering committee

## Dissertation

Select 12 credits from the following (use course from program of major advisor):

- BUS ADM 997 Doctoral Dissertation
- COMPSCI 998 Doctoral Thesis
- ELECENG 998 Doctoral Thesis
- HCA 890 Health Care Informatics Research and Thesis
- INFOS 998 Doctoral Dissertation
- NURS 997 Doctoral Dissertation
- PH 990 Research and Dissertation

Total Credits: 48
### Biomedical and Health Informatics, PhD

#### Public Health Informatics Track

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 701</td>
<td>Public Health Principles and Practice</td>
<td>3</td>
</tr>
<tr>
<td>PH 704</td>
<td>Principles and Methods of Epidemiology</td>
<td>3</td>
</tr>
<tr>
<td>PH 709</td>
<td>Public Health Informatics</td>
<td>3</td>
</tr>
<tr>
<td>COMPSCI 535</td>
<td>Algorithm Design and Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

**Required Statistics & Quantitative Methods**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 702</td>
<td>Introduction to Biostatistics</td>
<td>3</td>
</tr>
<tr>
<td>PH XXX</td>
<td>Seminar in Biostatistics and Bioinformatics</td>
<td>1</td>
</tr>
<tr>
<td>PH 713</td>
<td>Analyzing Observational and Experimental Data</td>
<td>3</td>
</tr>
<tr>
<td>PH XXX</td>
<td>Data Management, Visualization, and Advanced Statistical Computing</td>
<td>3</td>
</tr>
</tbody>
</table>

**Track Electives**

**Computing and Applications**
- Select 6 credits with approval of advisor and steering committee

**Quantitative Analysis**
- Select 6 credits with approval of advisor and steering committee

**Dissertation**
- Select 12 credits from the following (use course from program of major advisor):
  - BUS ADM 997: Doctoral Dissertation
  - COMPSCI 998: Doctoral Thesis
  - ELECENG 998: Doctoral Thesis
  - HCA 890: Health Care Informatics Research and Thesis
  - INFOST 998: Doctoral Dissertation
  - NURS 997: Doctoral Dissertation
  - PH 990: Research and Dissertation

| Total Credits | 46 |

### Translational Bioinformatics Track

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select one of the following:</td>
<td>2-3</td>
<td></td>
</tr>
<tr>
<td>BIO SCI 490</td>
<td>Molecular Genetics</td>
<td></td>
</tr>
<tr>
<td>MCW 20240</td>
<td>Translational Genetics, 2 cr</td>
<td></td>
</tr>
</tbody>
</table>

| Select one of the following: | 3 |
| PH XXX | Introduction to Bioinformatics, 3 cr       |         |
| MCW 17201 | Bioinformatics I: Introduction to Bioinformatics, 3 cr |         |
| MARQ BIIN 6000 | Introduction to Bioinformatics, 3 cr   |         |
| MARQ BIOL 5201 | Genomics and Bioinformatics, 3 cr   |         |

| Select one of the following: | 2-3 |
| PH XXX | Translational Bioinformatics, 3 cr       |         |
| Or both of the following: |         |
| MCW 20100 | Introduction to Clinical and Translational Research, 1 cr |         |
| and MCW 20261 | Clinical Trial Design, 1 cr |         |

| Select one of the following: | 3 |
| COMPSCI 425 | Introduction to Data Mining               |         |

| ELECENG/COMPSCI | Introduction to Machine Learning, 711   |         |
| BUS ADM 741 | Web Mining and Analytics                |         |
| MARQ ENMA 6060 | Innovation and Technology, 3cr |         |

Select one of the following:
- HCA 760: Biomedical and Healthcare Terminology and Ontology
- BUS ADM 814: Enterprise Knowledge & Semantic Management
- COMPSCI 810: Knowledge Representation
- INFOST 714: Metadata, 3cr

| Select one of the following: | 2-3 |
| HCA 723 | Health Care Systems Applications - Administrative and Clinical |         |
| MCW 14230 | Product Development of Medical Devices, 2 cr |         |

**Quantitative Methods**
- Select 9 credits from the following: 9 credits
  - NURS 883: Quantitative Methods in Health Research
  - MATH 771: Theory of Probability
  - PH 702: Introduction to Biostatistics
  - PH XXX: Statistical Genetics and Genetic Epidemiology, 3 cr
  - PH XXX: Applied Quantitative Methods for Studying Population Health and Health Disparities, 3 cr

Select a maximum of one of the following:
- MCW 11200: Introduction to Epidemiology, 3 cr
- PH 704: Principles and Methods of Epidemiology

Select a maximum of one of the following:
- PH 711: Intermediate Biostatistics
- MCW 04201: Biostatistics II, 3 cr

**Track Electives**
- Select 9 credits with approval of advisor and steering committee

| Total Credits | 45-48 |

### Additional Requirements

**Major Professor as Advisor**

The Graduate School requires that the student have a major professor to advise, supervise and approve the program of study before registering for courses. The Biomedical and Health Informatics Steering Committee will assign the incoming student to a temporary Program Advisor at the
time of admission. Prior to the completion of 12 credit (9 credits for a part-time student), the student must select a major professor who will be the student's dissertation advisor. The student, in consultation with the major professor, develops a program of study which is submitted to the Biomedical and Health Informatics Steering Committee for approval. For subsequent changes, the student must file a revised program of study for approval.

**Doctoral Program Committee**
The Doctoral Program Committee is proposed by the Major Professor in consultation with the student by the end of the student's first year of enrollment. The Program Committee, subject to the approval of the Biomedical and Health Informatics Steering Committee, shall consist of the Major Professor and at least four graduate faculty members, including at least one with health care and/or medical background, and one with informatics background.

**Residence**
The student must meet Graduate School residence requirements.

**Qualifying Examination**
A qualifying examination must be taken to determine whether the student is qualified to perform advanced doctoral level work in biomedical and health informatics. This examination is administered by the steering committee and must be taken prior to the completion of 21 credits of coursework in the program.

**Doctoral Preliminary Examination**
The student is also required to take a preliminary examination after all the coursework is completed and prior to the advancement of candidacy to determine the student's preparation for independent research. Prior to the examination, the student must present a proposal for a doctoral dissertation. The preliminary examination may cover both graduate course material and the dissertation proposal. The preliminary examination must be successfully completed within five years of initial enrollment.

**Dissertation**
The candidate must complete a dissertation presenting independent original research that adds to the existing body of knowledge in biomedical and health informatics. It should be of such caliber that warrants publication in respected journals.

**Dissertation Defense**
The final oral examination will be an oral defense of the dissertation but may also cover the general field of the primary area of study. The examination may not be taken until all other degree requirements are satisfied. A majority of the examination committee members must approve the dissertation in order for the student to pass. The final oral examination must be taken within five years after passing the preliminary examination. Candidates who exceed this time limit may be required to retake the preliminary examination and be admitted to candidacy a second time.

**Time Limit**
All components of the PhD program must be completed within 10 years of matriculation.