A supplemental guide for graduate students

Students admitted to the IE graduate programs can adhere to the specific degree requirements and simultaneously customize a course of study in healthcare systems engineering. Students should refer to the graduate student handbook for complete details on degree requirements and understand it thoroughly. In most cases, students may elect at least three 500-level IE courses and two 500-level non-IE courses.

This document is prepared as a supplemental guide that outlines some of the frequently selected relevant courses, the key topics and student projects that address healthcare, and information about graduate student opportunities with the Center for Integrated Healthcare Delivery Systems (CIHDS). It also provides information about the faculty interests, research, and employment perspectives as they relate to healthcare.

The cutting edge of medicine and clinical trials have brought amazing advances in treating illness. Innovative manufacturers in the areas of pharmaceuticals, medical devices, and medical equipment have contributed to life-saving treatments. Yet the frustrating paradox remains that even the most technologically advanced healthcare systems are fraught with error and waste. Industrial engineers are uniquely suited to work as integrators who develop solutions to such problems.

Safe, effective, patient-centered, timely, efficient, and equitable care – these are six quality aims envisioned for the healthcare system. Crossing the Quality Chasm
The Institute of Medicine
Healthcare Systems Engineering Course

**IE 597 Healthcare Systems Engineering.** The course develops a fundamental understanding of quantitative tools used to perform system analyses and make decisions in the healthcare context. Knowledge of mathematical modeling, time series analysis, and experimental design (such as covered in IE 405, IE 425, IE 433, IE 434) is required. Contact: H. B. Nembhard / P. Griffin

The course objectives are to supply students with the knowledge to identify, evaluate and mitigate health care delivery problems through the use of interactive lectures, case studies and real-world application projects. After completing this course, students should be able to:

1) identify the needs, requirements and limitations of a health care system;
2) evaluate health care system quality; and
3) model and improve health care system performance.

Key Topics Applied in Healthcare:
- systems view of healthcare delivery
- patient flow
- collecting and analyzing healthcare data
- disparities in healthcare
- national healthcare databases
- lean thinking in healthcare operations
- six sigma in clinical operations
- cost-effectiveness modeling
- health logistics
- incentives in healthcare
- capacity management
- modeling of infection control in health operations

Past Student Projects in Healthcare:

- **Cost Effectiveness of Aspirin for the Prevention of Heart Disease**
- **Framework for Real-Time Trend Detection and Application to Control Charts in Healthcare**
- **Finding Hidden Relationships in Healthcare Data using Clustering Techniques**
- **Analyzing the effect of Risk Factors and Screening on Cervical Cancer**
- **The Role of Patient Adherence in HIV Costs for US Veterans**
- **Chronic Disease and Depression in Adolescents: Findings and Applications using ADD-HEALTH Data**
- **Understanding Common Patient Trends to Reveal Pre-Screening Techniques**
- **Determining the Effectiveness of Vaccinating Boys for HPV**
Relevant IE Courses


Key Topics Applied in Healthcare: Scheduling models may be applied to patient scheduling, healthcare worker scheduling, or operating room scheduling.

IE 509: Operations Research: Waiting Line Models. Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: IE 516. Contact: M. J. Chandra / G. Pang

Key Topics Applied in Healthcare: patient flows in hospitals • delay reduction • admission control and routing of patients • personnel staffing and scheduling • management of hospital facilities • design of wards and waiting rooms in hospitals

IE 511: Experimental Design in Engineering. Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisite: IE 323. Contact: E. Castillo

Key Topics Applied in Healthcare: These topics can be applied in medical devices design and pharmaceutical development.

IE 516: Applied Stochastic Processes. Discrete and continuous time stochastic processes, including discrete time Markov chains, Poisson processes, continuous time Markov chains, and renewal processes. Prerequisite: IE 322 or STAT 318. Contact: T. Yao

Key Topics Applied in Healthcare: These topics can be applied in modeling disease spread and medical errors.

IE 520 Multiple Criteria Optimization. Study of concepts and methods in analysis of systems involving multiple objectives with applications in engineering, economic, and environmental systems. Prerequisite: IE 405 or BA 450. Contact: A. Ravindran

Key topics Applied in Healthcare: ranking methods • analytic hierarchy process (AHP) • data envelopment analysis (DEA) • bi-criteria optimization • goal programming

Past Student Projects in Healthcare: Cardiovascular Disease Control; Radiation Therapy Planning; Hospital Evaluation by DEA
**IE 522: Discrete Event Systems Simulation.** The study of the fundamentals of discrete event simulation, including event scheduling, time advance mechanisms, random variate generation, and output analysis. Prerequisite: IE 425. Contact:

Key Topics Applied in Healthcare: process flow • demand-capacity matching • resource requirements • bottlenecks

Past Student Projects in Healthcare: *Patient Flow in the Emergency Department*

**IE 557: Human-in-the-loop Simulation.** Use of object-oriented tools for developing interactive, real-time simulations and for designing simulation interfaces. Prerequisites or Concurrent: IE 522. Contact: L. Rothrock

Key Topics Applied in Healthcare: A remote disease management call-center prototype is discussed in class.

**IE 558: Engineering of Cognitive Work.** Information processing and decision making models of the human in the modern workplace, emphasizing visual inspection and other industrial applications. Prerequisites: IE 323 and IE 408. Contact: L. Rothrock

Key Topics Applied in Healthcare: Discussion of biases in physician decision making in context of judgment and decision making research.

**IE 562: Expert Systems Design for Industrial Engineering.** This course covers topics in artificial intelligence problem solving, search techniques, first-order logic, knowledge based systems, MYCIN and further developments, distributed intelligence, natural language processing, and neural networks. Contact: S. Kumara

Key Topics Applied in Healthcare: The topics are useful in building logical inference systems in all fields including healthcare.

**IE 570: (SC&IS) Operations Research in Supply Chain.** Use of operations research models and methods for solving problems in supply chain systems. Prerequisites: IE 405, IE 425 or SC&IS 510. Contact: A.R. Ravindran / P. Griffin

Key Topics Applied in Healthcare: Forecasting • health facility location • network design • healthcare logistics

Past Student Projects in Healthcare: *Forecasting hospital supplies and supplier selection; Supply chain design for distribution of nets for malaria prevention.*
IE 582: Advanced Information Technology for Industrial Engineering. This course covers advanced topics related to databases, data mining, software agents, web services, distributed systems and real time data analysis, ubiquitous computing both from theoretical and applied perspectives. Contact: S. Kumara

Key Topics Applied in Healthcare: All of the topics in this course are directly related to healthcare informatics.

IE597: Industrial Engineering Data Modeling. Methods for modeling data from a variety of manufacturing, health, and service systems. Prerequisite: IE 323. Contact: D. Nembhard

Key Topics Applied in Healthcare: Association rule mining • factor analysis

Past Student Projects in Healthcare: *The Performance of Nurse Rosters*

IE597F/IE530: Financial Engineering. Cash flow analysis, options pricing, real options, and applications. Prerequisites: MATH 231 and IE 516. Contact: T. Yao

Key Topics Applied in Healthcare: Interface of finance operations • and risk management • revenue management

Past Student Projects in Healthcare: *Dynamic Capacity Expansion with Outsourcing Options for New Drug Introduction*
Relevant HPA Courses

**HPA 503: Health Services Organizational Behavior.** A systematic application of the principles of organizational behavior to understanding professional roles in health services organizations.

**HPA 520: Introduction to Health Services Organizations and Delivery.** Introduction to health systems, health services organization and health care delivery focused on trends, problems and issues.

**HPA 521: Research Seminar on Health Services Organization and Delivery.** An examination of seminal and current research on health services organization and delivery, emphasizing costs, access and quality. Prerequisite or Concurrent: HPA 520

**HPA 523 Managerial Epidemiology.** Introduction to the principles and methods of managerial epidemiology and its application to health care.

**HPA 528: Health Data Analysis for Research.** Introduction to data sources and use of software for data management and analysis in health services research.

**HPA 545: Introduction to Health Economics.** Survey of the application of economics to the roles of markets and government in health care.

**HPA 551: Quality Improvement in Healthcare.** Examination of major approaches to performance improvement in contemporary healthcare systems. Concurrent: HPA 523

**HPA 561: Introduction to Research Design in Health Services Research.** Review and critical analysis of state-of-the-art health services research methods.

**HPA 563 Organizational Studies in Health Services Research.** Applications of theoretical and empirical tools of organizational studies in the delivery of health care. Prerequisite: HPA 503 or equivalent

**HPA 566 Advanced Methods in Health Services Research I.** Advanced topics course focusing on extensions of the ordinary least squares regression model and nonlinear methods in health services research. Prerequisite: HPA 564 or equivalent

**HPA 597A Advanced Methods in Health Services Research II.** Application of advanced methods to health services research topics focused on empirical approaches to causal inference in nonexperimental data. Prerequisite: HPA 564 or equivalent
HPA 805 Change Leadership in Health Services Organizations. Exploration of diagnostic and intervention strategies employed in planned change in health services organizations and programs.

HPA 822 Clinical Issues for Health Services Management. Introduction to current clinical issues in health services organizations focusing on the role of managers.

HPA 850 Health Care Marketing. Introduction to the theory, concepts, skills, and principles of marketing applied to health related organizations and networks. Prerequisite: HPA 520

Relevant IST Courses

IST 521 Human-Computer Interaction: The User and Technology. Users, models of users, developing the models, technology for creating interfaces; examples of good research and implications for Human-Computer Interface (HCI) design. Contact M. B. Rossen

IST 522 Models and Theories of Human-Computer Interaction. This course covers the theoretical foundations of human-computer interaction that prepares students in planning and conducting research in HCI. Contact: J. M. Carrol

IST 597C Introduction to Medical Informatics. This course covers a broad range of topics including healthcare organizations, database and other medical technologies, socio-technical issues in medical informatics, modeling and design of medical information systems, and standards. This course also discusses the latest research opportunities and challenges in medical informatics. Contact: M. Reddy / J. Wang
Graduate Student Opportunities with the Center for Integrated Healthcare Delivery Systems (CIHDS)

The Center for Integrated Healthcare Delivery Systems (CIHDS) was formed with a mission to capitalize on the existing strengths of Penn State and promote a holistic approach to understanding and solving problems of access and quality in healthcare. The Center is a joint initiative of Penn State University's Colleges of Medicine, Engineering, Information Sciences & Technology, and Health & Human Development and the Office of the Vice President for Research.

The CIHDS Scholars program is directed at attracting graduate and post-graduate students with an interest in healthcare delivery. These students work with faculty advisors on research themes that are key to the Center's scope. The scholars become active participants in the Center and present their projects at the annual workshop. Each scholar receives a cash award and certificate for completing the program. Some past projects have included:

- Optimizing Patient Flow in the Emergency Department
- Increasing Quality Outcomes with Pay-for-Performance
- A Risk Assessment of Medical Devices
- Development of an Integrated Model to Predict Patient Compliance
- Health Information Technologies: Privacy and Security
- Healthcare Data Visualization for Chronic Care Management
- Supporting Multi-Disciplinary Team Collaboration through the Electronic Medical Record
- Critical Factors in Medical Device Development

Many of the projects have enabled scholars to work with graduate students and faculty outside of the IE department, thus expanding the base of their learning experience. The CIHDS projects often become a component of students’ masters or doctoral theses and/or the basis for project work in their classes.

CIHDS was recently made a five-year award to develop the PSU site of the NSF Center for Health Organization Transformation (CHOT). This award has planned research expenditures of $1.2 million which includes co-funding by NSF, industry members, and university cost-sharing. It will allow for immediate implementation of high-priority research projects that span clinical decision support, chronic care, healthcare management and other areas. Several opportunities are expected to arise for graduate students as well as faculty and industry partners under this award.

For more information, see <www.CIHDS.psu.edu>.
IE Faculty and HSE Interests

Dr. Andris Freivalds, Professor
- Interests: ergonomic design of medical products and instrumentation for more efficient user operation and patient monitoring

Dr. Paul Griffin, Peter and Angela Dal Pezzo Department Head Chair
- Interests: financial incentives and cost-effectiveness in healthcare; infection modeling; health logistics

Dr. Catherine Harmonosky, Associate Professor
- Interests: improving patient flow in health care systems, improving efficiency and coordination within health care delivery systems

Dr. Soundar Kumara, Allen E. Pearce/Allen M. Pearce Chaired Professor
- Interests: health information technology

Dr. David Nembhard, Associate Professor
- Interests: health systems data mining; staffing and scheduling models of health workers with heterogeneous skills

Dr. Harriet Black Nembhard, Professor and Director of the Center for Integrated Healthcare Delivery Systems (CIHDS)
- Interests: quality improvement in healthcare systems; data visualization and multivariate modeling of healthcare data; decision making in healthcare

Dr. Gul E. Okudan-Kremer, Associate Professor
- Interests: complex decision analysis in healthcare settings

Dr. Guodong (Gordon) Pang, Assistant Professor
- Interests: healthcare as a large-scale service system; stochastic modeling and queuing systems in hospitals and clinics

Dr. Vittal Prabhu, Professor
- Interests: models for planning, control and sensing of healthcare and prevention services

Dr. A. “Ravi” Ravindran, Professor
- Interests: multi-objective models for health systems planning; communicable disease control and prevention; radiation therapy planning; DEA and AHP models for hospital evaluation
Dr. Ling Rothrock, Associate Professor
- Interests: human judgment and decision making in healthcare delivery; human-in-the-loop simulations of healthcare delivery process

Dr. Tao Yao, Associate Professor
- Interests: financial incentives optimization, stochastic models, and game theory in healthcare applications

IE PhD Students Conducting HSE Research

Seth Hostetler (Ph.D. advisor: D. J. Medeiros; expected graduation: 2014)
Mr. Hostetler is developing models for supply logistics in hospitals to balance cost, service level, and responsiveness.

Yun Cheol Kang (Ph.D. advisor: V. Prabu; expected graduation: 2014)
Mr. Kang is developing information feedback and dynamic optimal control systems for health care and prevention services.

Emily Hyojung Kang (Ph.D. advisor: H. B. Nembhard; expected graduation: 2014)
Ms. Kang is examining quality and process improvement approaches for hospital admissions and care coordination.

Hyunji Lee (Ph.D. advisor: P. Griffin; expected graduation: 2013)
Ms. Lee is developing mathematical models to help determine the impact of health policy interventions on access and coverage.

Praewpran Prayadsab (Ph.D. advisor: P. Griffin; expected graduation: 2014)
Ms. Prayadsab is using public health data to determine the impact of Medicaid reform on health outcomes and developing appropriate measures of disease burden for children.

Yi-Shan Sung (Ph.D. advisor: S. Kumara; expected graduation: May 2014)
Ms. Sung is working on network analytics problems on large scale networks. The resulting clusterings are used in building commonalities in clinical parameters among the participating members.

Renfei Yan (Iris) (Ph.D. advisor: P. Griffin; expected graduation: 2013)
Ms. Yan is investigating cost-effective intervention strategies for reducing incidence of communicable disease in resource-constrained countries.

Hui Yang (Ph.D. advisor: S. Kumara; expected graduation: December 2013)
Mr. Yang is working on developing the visualization dashboards and standards for IT Infrastructure for patient collaborative healthcare. These visualizations also include multi-scale social networks.
IE Dissertations, Theses and Papers in HSE  
(2007-present)

2012


2010


2009


2008


2007

IE Faculty Publications in HSE (2007-present)

2012


2011


2010


2009


2008


2007


"What do you want to do after you graduate?" was the question a representative from Siemens asked me during the Spring 2010 CIHDS conference. After briefly looking over my team’s poster on payment systems for care providers she went on to talk about how the rare combination of an analytical engineering mind with a capacity to not only understand but also suggest solutions to our nation’s healthcare problems really is. As a new graduate student in the Penn State industrial engineering department, I had always had the intention of gearing my coursework with more of a health systems geared curriculum for myself. I was well aware of how this interdisciplinary field was making quite an innovative change within academia and industry by developing new strategies and consequent results to prove its need every day.

As there is no specific track for this discipline offered at Penn State, I took courses and aimed the projects within them to healthcare related topics using quintessential industrial engineering skills like simulation, algorithmic modeling and statistics. With the flexibility in courses and thesis work offered by professors and the department, whether holistically or discretely related to healthcare, I was able to build a strong resume that reflected my interests. In retrospect, however, the most important opportunity remains involvement in the Center for Integrated Healthcare Delivery Systems. This alliance exposed me to multiple research areas, industry needs, and interdisciplinary collaboration. I believe these opportunities allowed me to be an exceptionally strong candidate during my pursuit for a career in health systems.

I was recently able to accept an offer with Siemens Healthcare for the coveted Siemens Graduate Program. My career in healthcare management will start with three eight-month assignments along with extensive classroom training. I will be rotating through three different functions (e.g. sales, marketing) within the Siemens Molecular Imaging, including one assignment abroad. After this, I will start work within Molecular Imaging in an area of my interest. As this position required relevant work experience or related technical knowledge in the discipline, pursuing a health systems approach to industrial engineering not only fulfilled this requirement but made a particularly valuable impression to leaders at Siemens.
Why do employers want IEs with a background in healthcare?

According to the U.S. Bureau of Labor Statistics, the healthcare industry will add 3.2 million new jobs between 2008 and 2018, the largest increase of any industry. Students who focus their studies in healthcare systems will find that employers are eager to attract them in order to respond to the many challenges across healthcare delivery, supply chains, diagnostics, R&D, and other areas.

Penn State was recently ranked as the top choice of recruiters in a Wall Street Journal survey (9/13/10). Companies such as General Electric, Geisinger Health, Lockheed Martin, IMS Health, Johnson & Johnson, Siemens, Verizon and many others are seeking IE graduates for positions having healthcare impact and responsibilities. These companies regularly recruit on our campus. Learn more by visiting <www.studentaffairs.psu.edu/career>.

For More Information

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