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# MIE 1616S – Research Topics in Healthcare Engineering

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The course is offered as a PhD Reading Course in McGill University, where Prof. Vedat Verter is the lead instructor. He can be reached at [Vedat.verter@mcgill.ca](mailto:Vedat.verter@mcgill.ca)

**Background:**

Healthcare Engineering has existed for decades. In the late 70's and early 80's, industrial engineering departments were quite common in hospitals across North America. During the late 80's and 90's, for some reason, there was a dramatic decrease in the use of industrial engineers. I suspect that IEs were not working on the issues that were "keeping the CEO awake at night". However, the profession has survived, often under the name "Management Engineering". The term "healthcare engineering" is intended to convey the general philosophy of design and analysis concepts applied to building a better healthcare system.

There have been a number of changes over the past decade. First, the medical establishment began to recognize that the industry has serious efficiency and operational problems (poor resource utilization, waste of money, high error rates, etc.) Much of this change in attitude has been fostered by groups like the Institute for Healthcare Improvement ([www.ihl.org](http://www.ihl.org)). Leaders have begun to realize that industrial engineers have the tools necessary for dealing with these issues. Early work in the field was generally

individual projects where industrial engineers were asked to look at scheduling small groups of nurses or operating rooms. Gradually, the scope of the problems considered has grown to include patient flow and bed allocation. Recent projects have considered more strategic decisions involving health policy such as immunization guidelines and system-wide resource allocations. There has been a considerable growth in interest from the medical community and the supply of healthcare management engineering specialists is not keeping pace with the demand.

**Purpose:**

The purpose of this course is to provide an overview of current OR research in healthcare and to develop the insight required in order to do relevant and significant research in this field. The course attempts to provide an overview to some of the major research topics in the field, but the course also provides an opportunity for students to demonstrate “critical analysis” of the literature.

Graduate students in this class should have an introductory level background in the necessary tools of OR such as mathematical programming, stochastic processes, queueing theory, statistical modelling, decision analysis and dynamic programming. Students must have sufficient knowledge to be able to read and understand the various papers. The majority of the papers involve applications of OR to healthcare problems.

**Course Description:**

This is a seminar-based course in which we will review a variety of papers in the field of healthcare OR. We will survey and evaluate several papers within topic areas and try to identify areas for potential future research. Some papers will be distinctly OR, while others will come from researchers in the field of healthcare policy and healthcare economics. One thing that you will notice as we go through the literature is that the area of healthcare engineering is interdisciplinary in nature, and encourages solutions that are derived from various areas of expertise. This interdisciplinary approach is also encouraged through the many funding bodies that currently support healthcare engineering research in North America. The Canadian Institute of Health Research, CIHR, (<http://www.cihr-irsc.gc.ca>) funds the majority of healthcare research in Canada. It is composed of 14 virtual ‘institutes’ that represent all facets of health research. The Institute of Health Services and Policy Research, IHSPR, is most related to the type of collaborative research discussed above. It supports innovative research, capacity-building and knowledge translation in order to improve health care service delivery. In 2001 and 2004, IHSPR was involved with national consultations on health services priorities entitled “Listening for Direction”. The result of these consultations was a set of priorities for Canadian researchers in the area of health care policy and management. Of course, not all of the topics are relevant to Healthcare Engineering, but many of the readings and articles discussed in this class will align with the most recent set of priorities:

<b>Research Themes</b>	<b>Key Components</b>
Workforce planning, training, and regulation	<ul style="list-style-type: none"> <li>• Value of inter-professional team care in different settings</li> <li>• Forecasting models</li> <li>• Scopes of practice and health professional regulation</li> </ul>

	<ul style="list-style-type: none"> <li>• Relationship between extent/nature of training and health outcomes</li> </ul>
Management of the healthcare workplace	<ul style="list-style-type: none"> <li>• How changing demographics are leading to changing expectations in the workplace</li> <li>• Factors generating organizational commitment and productivity by healthcare professionals</li> <li>• Identification of leaders in healthcare</li> </ul>
Timely access to quality care for all	<ul style="list-style-type: none"> <li>• Waiting time management for specialized and diagnostic services</li> <li>• Timely access to primary and community care</li> <li>• Improving access for rural and remote communities and for minority and vulnerable groups</li> </ul>
Managing for quality and safety	<ul style="list-style-type: none"> <li>• Improving quality, uptake of clinical best practices</li> <li>• Improving patient safety, adverse event reduction systems</li> </ul>
Understanding and responding to public expectations	<ul style="list-style-type: none"> <li>• Impact of market-driven influences</li> <li>• Interpersonal, attitudinal, cognitive, and risk-perception influences</li> <li>• Role of the media in influencing public attitudes and public expectations of health services.</li> <li>• Effectiveness of alternative approaches to public engagement</li> </ul>
Sustainable funding and ethical resource allocation	<ul style="list-style-type: none"> <li>• Ethical framework for resource allocation</li> <li>• Models for institution-level resource allocation</li> <li>• Evidence on system efficiencies and resource redeployment</li> <li>• Effects and effectiveness of public-private partnerships</li> </ul>
Governance and accountability	<ul style="list-style-type: none"> <li>• Selection, role, and use of individual performance indicators</li> <li>• Current organizational frameworks for using performance indicators</li> <li>• The link between population-based funding and accountability</li> <li>• Implications of foreign experiences of public-private partnerships for Canada</li> <li>• Intelligence from regionalization experiences</li> </ul>
Managing and adapting to change	<ul style="list-style-type: none"> <li>• Models and mechanisms of knowledge translation</li> <li>• Intra-organizational management structures</li> </ul>
Linking care across place, time, and settings	<ul style="list-style-type: none"> <li>• Improving chronic disease management</li> <li>• Caregiver support and informal and voluntary care</li> <li>• Technology and chronic disease management</li> </ul>
Linking public health to health service	<ul style="list-style-type: none"> <li>• Surge capacity: How to organize health services to cope with emergencies?</li> <li>• Relationship between specific disease prevention or health promotion products/services on need for traditional healthcare services</li> <li>• Public health threats &amp; the need for healthcare/public health professionals</li> </ul>

## Required Materials:

All materials for the course will be contained on the class CD, or alternatively, downloaded from the course website. All articles have been retrieved from University of Toronto library full-text databases.

## Additional Reference Materials:

1. Brandeau, M, Sainfort, F. and Pierskalla, W.P. , *Operations Research and Health Care*, Kluwer Academic Publishers, 2004.
2. Vissers, J. and Beech, R., *Health Operations Management: Patient Flow Logistics in Health Care*, Routledge: London, 2005
3. Ronen, B. and Pliskin, J.S., *Focused Operations Management for Health Services Organizations*, Wiley and Sons: San Francisco, 2006
4. **Hall, R.W., (ed.)** *Patient Flow: Reducing Delay In Healthcare Delivery*, Springer, 2007.
5. **Langabeer, J.R.**, *Health care operations management: a quantitative approach to business*, Jones & Bartlett Publishing Company, 2007
6. **Reid, P.P., Compton, W.D., and Grossman, J.H.**, *Bulding A Better Delivery System: A New Engineering/Health Care Partnership*, National Academy Press; 1 edition (Jan 1 2005)

**Note: Somayeh Sadat has created a “listmania!” on Amazon.ca called “Quantitative Methods in Health Care”. The list contains a number of additional interesting books.**

## Class Schedule (Tentative):

Jan 20	Healthcare systems in various countries
Jan 27	Operating Room Scheduling
Feb 3	Nurse scheduling
Feb 10	Location of facilities
Feb 24	Health Technology Assessment
Mar 3	Emergency Medical Services location
Mar 10	Pharma
Mar 17	Emergency Department
Mar 24	Safety
Mar 31	Screening
Apr 7	Forecasting

**The outline below is a draft and the dates will be revised**

	Date	Topic	Paper(s)
1	Jan 13	Course Introduction	<ul style="list-style-type: none"> <li>• Course Outline</li> <li>• Brief overview of Canadian healthcare system</li> <li>• Class discussion about how Industrial Engineering ‘fits’ into each of the priority <i>research themes</i> identified by IHSPR/CIHR.</li> <li>• Each person should select a ‘country’ to investigate and present a short summary of at next week’s class. Some of the themes that could be covered: What is covered within the public system? Who is covered? Who pays? Overview of historical background. How is care delivered? How does it compare with Canada? Some of the countries that I hope we will include are: UK, US, France, Sweden, Australia, New Zealand, Denmark, Germany, Japan, Netherlands, Spain, Austria, Switzerland.</li> </ul>
2	Jan 17	Health Care Delivery Systems – A Global Comparison	<p>OECD technical reports: Denmark, Hungary, Germany, Spain, Netherlands, Australia, Switzerland (see class wesite)</p> <p>-----</p> <p>Some additional references:</p> <p><a href="#">Ankjær-Jensen, Anni, Rosling, Pernille, &amp; Bilde, Lone. 2006. Variable prospective financing in the Danish hospital sector and the development of a Danish case-mix system. <i>Health Care Management Science</i>, 9(3): 259-268.</a></p> <p><a href="#">Beck, Konstantin. 2000. Growing importance of capitation in Switzerland. <i>Health Care Management Science</i>, 3(2): 111-119.</a></p> <p><a href="#">Gaal, Peter, Stefka, Nóra, &amp; Nagy, Júlia. 2006. Cost accounting methodologies in price setting of acute inpatient services in Hungary. <i>Health Care Management Science</i>, 9(3): 243-250.</a></p> <p><a href="#">Oostenbrink, J. B., &amp; Rutten, F. F. H. 2006. Cost assessment and price setting of inpatient care in the Netherlands. the DBC case-mix system. <i>Health Care Management Science</i>, 9(3): 287-294.</a></p> <p><a href="#">Peacock, Stuart, &amp; Segal, Leonie. 2000. Capitation funding in Australia: Imperatives and impediments. <i>Health Care Management Science</i>, 3(2): 77-88.</a></p> <p><a href="#">Sánchez-Martínez, Fernando, Abellán-Perpiñán, José-María, Martínez-Pérez, Jorge-Eduardo, &amp; Puig-Junoy, Jaume. 2006. Cost accounting and public reimbursement schemes in Spanish hospitals. <i>Health Care Management Science</i>, 9(3): 225-232.</a></p> <p><a href="#">Schreyögg, Jonas, Tiemann, Oliver, &amp; Busse, Reinhard. 2006. Cost accounting to determine prices: How well do prices reflect costs in the German DRG-system? <i>Health Care Management Science</i>, 9(3): 269-279.</a></p>

3	Jan 24	Scheduling – OR	<p><a href="#">Blake, John T., &amp; Donald, Joan. 2002. Mount Sinai hospital uses integer programming to allocate operating room time. <i>Interfaces</i>, 32(2): 63.</a></p> <p><a href="#">Jebali, Aida, Hadj Alouane, Atidel B., &amp; Ladet, Pierre. 2006/0. Operating rooms scheduling. <i>International Journal of Production Economics</i>, 99(1-2): 52-62.</a></p>
4	Jan 31	Scheduling - Nurses	<p><a href="#">Burke, E. K., Causmaecker, P. D., Berghe, G. V., &amp; Landeghem, H. V. 2004. The state of the art of nurse rostering. <i>Journal of Scheduling</i>, 7(6): 441-499.</a></p>
5	Feb 7	Location – Facilities	<p><a href="#">Johnson, Michael P., Gorr, Wilpen L., &amp; Roehrig, Stephen. 2005. Location of service facilities for the elderly. <i>Annals of Operations Research</i>, 136(1): 329.</a></p> <p><a href="#">Verter, Vedat, &amp; Lapierre, Sophie D. 2002. Location of preventive health care facilities. <i>Annals of Operations Research</i>, 110(1-4): 123-132.</a></p>
6	Feb 28	Location – EMS	<p><a href="#">Budge, A Ingolfsson and E Erkut and S. 2003. Simulation of single start station for Edmonton EMS. <i>The Journal of the Operational Research Society</i>, 54(7): 736.</a></p> <p><a href="#">Harewood, S. I. 2002. Emergency ambulance deployment in Barbados: A multi-objective approach. <i>Journal of the Operational Research Society</i>, 53(2): 185.</a></p>
7	Feb 14	Health Technology Assessment	<p><a href="#">Cooper, K., Brailsford, S. C., Davies, R., &amp; Raftery, J. 2006. A review of health care models for coronary heart disease interventions. <i>Health Care Management Science</i>, 9(4): 311-324.</a></p> <p><a href="#">Sloane, Elliot B., Liberatore, Matthew J., Nydick, Robert L., Luo, Wenhong, &amp; Chung, Q. B. 2003. Using the analytic hierarchy process as a clinical engineering tool to facilitate an iterative, multidisciplinary, microeconomic health technology assessment. <i>Computers and Operations Research</i>, 30(10): 1447-1465.</a></p>
8	Mar 7	Pharmaceuticals	<p><a href="#">Vernon, John A., Hughen, W. K., &amp; Johnson, Scott J. 2005. Mathematical modeling and pharmaceutical pricing: Analyses used to inform in-licensing and developmental Go/No-go decisions. <i>Health care management science</i>, 8(2): 167.</a></p> <p><a href="#">Zaric, Gregory S., Brandeau, Margaret L., &amp; Barnett, Paul G. 2000. Methadone maintenance and HIV prevention: A cost-effectiveness analysis. <i>Management Science</i>, 46(8): 1013.</a></p>
9	Mar 14	Emergency Departments	<p><a href="#">Lane, D. C., Monefeldt, C., &amp; Rosenhead, J. V. 2000. Looking in the wrong place for healthcare improvements: A system dynamics study of an accident and emergency department. <i>The Journal of the Operational Research Society</i>, 51(5): 518.</a></p> <p><a href="#">Sinreich, David, &amp; Marmor, Yariv, 2005. Emergency department operations: The basis for developing a simulation tool. <i>IIE Transactions</i>, 37(3): 233-245.</a></p>

<b>10</b>	Mar 21	Public Health - Screening	<a href="#">Günes, Evrim D., Chick, Stephen E., &amp; Aksin, O. Z. 2004. Breast cancer screening services: Trade-offs in quality, capacity, outreach, and centralization. <i>Health Care Management Science</i>, 7(4): 291-303.</a> <a href="#">Harper, P. R., &amp; JONES, S. K. 2005. Mathematical models for the early detection and treatment of colorectal cancer. <i>Health Care Management Science</i>, 8(2): 101-109.</a>
<b>11</b>	Mar 28	Forecasting Health Care Need	<a href="#">Honeycutt, Amanda A., Boyle, James P., Broglio, Kristine R., Thompson, Theodore J., Hoerger, Thomas J., Geiss, Linda S., &amp; Venkat Narayan, K. M. 2003. A dynamic markov model for forecasting diabetes prevalence in the united states through 2050. <i>Health Care Management Science</i>, 6(3): 155-164.</a> <a href="#">Ohinmaa, Arto, Jacobs, Phillip, Simpson, Scot, &amp; Johnson, Jeffrey A. 2004. The projection of prevalence and cost of diabetes in Canada 2000 to 2006. <i>Canadian Journal of Diabetes</i>, 28(2): 1-8.</a>
<b>12</b>	Apr 4	Patient Safety	<a href="#">McFadden, Kathleen L., Stock, Gregory N., Gowen, Charles R., III, &amp; Cook, Patricia. 2006. Exploring strategies for reducing hospital errors. <i>Journal of Healthcare Management</i>, 51(2): 123.</a> <a href="#">Naveh, Eitan, Katz-Navon, Tal, &amp; Stern, Zvi. 2005. Treatment errors in healthcare: A safety climate approach. <i>Management Science</i>, 51(6): 948-960.</a>
<b>13</b>	Apr 11	Course Wrap Up	Summary of lessons learned and trends seen. Plans for future research.

Each 'seminar' will be led by two students. The research will be presented, OR concepts explained and described, and the research compared and critiqued. For most session, I have provided two papers that present similar topics, but with a different approach. During your background preparation for the two papers, you may come across other papers that you feel add to the topic and you may certainly discuss those as well. In addition, there are several other files on the class-CD that you may wish to use as background material, but feel free to bring in any relevant and interesting information that you find.

ALL students will read each paper before the presentations and are expected to participate in a meaningful way. Class discussion will run after the presentation; students are expected to bring insights that may not have been developed during the presentation. Students will receive a mark based on their level of participation in each class. The students responsible for presenting the topic/papers should assume that the audience has read the paper and understands it on a basic level.

Each student will lead two topic discussions and participate in the global comparisons of health care systems on the second day of classes. Each student will pick one country and prepare a 15 minute presentation describing how health care is delivered, funded and how physicians are remunerated. Following the presentations, there will be time to discuss how these systems compare to our own.

The final deliverable will be a take-home essay that will build upon the concepts learned in class. It will be no longer than 2000 words. The topic will be handed out on April 4 and essay handed in on April 11.

## Grading:

Class Participation	20%
Mini-presentation of OECD country	15%
Discussion Leader #1	20%
Discussion Leader #2	20%
Take-home Essay (2000 word max) Topic TBA (Regionalization?)	25%
	100%

## Analysis of Papers:

When you do your presentation, you may find the following questions help guide a critical analysis of the paper. (Thank you to M. Putterman for his original list that I have added to)

**Problem:** Why was this paper written? What problem was it trying to solve? Is the problem important? Why or why not? Is the problem real or contrived? Is it still relevant?

**Formulation:** How was the problem formulated? Is this the best way possible? What other formulations could be used? Was the level of detail appropriate? Why was this formulation chosen?

**Methodology and Analysis:** Is it appropriate and correct? Why was each step done? (When presenting be sure to go through details at an appropriate level. This doesn't mean repeating derivations or proofs line by line but it does mean that you have to understand them and be able to convey the main ideas.)

**Results:** What are the key results of the paper? Are they complete? Do they address the problem that the paper was trying to solve? Are the results reproducible? Could they be generalized for other problems, locations?

**Further Directions:** What open problems remain and what extensions are possible? How would you follow them up? Are there good research questions that would extend this research?

**General Assessment of the Paper:** Was it well presented? What are its strengths and weaknesses?

**Comparison of Papers:** If both papers used different approaches, which one did you prefer? Under what circumstances would you prefer the other?