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*WTEC Panel Report on*

**OPERATIONS RESEARCH FOR  
HEALTH CARE DELIVERY SYSTEMS**

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## **OPERATIONS RESEARCH FOR HEALTH CARE DELIVERY SYSTEMS**

Sponsored by the National Science Foundation and the Agency for Healthcare Research and Quality.

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### **WTEC, Inc.**

WTEC provides assessments of foreign research and development in selected technologies under awards from the National Science Foundation, the Office of Naval Research, and other agencies. Formerly part of Loyola College's International Technology Research Institute, WTEC is now a separate non-profit research institute. Michael Reischman, Deputy Assistant Director for Engineering, is NSF Program Director for WTEC. Sponsors interested in international technology assessments and related studies can provide support for the program through NSF or directly through separate grants to WTEC.

WTEC's mission is to inform U.S. scientists, engineers, and policymakers of global trends in science and technology. WTEC assessments cover basic research, advanced development, and applications. Panels of typically six technical experts conduct WTEC assessments. Panelists are leading authorities in their field, technically active, and knowledgeable about U.S. and foreign research programs. As part of the assessment process, panels visit and carry out extensive discussions with foreign scientists and engineers in their labs.

The WTEC staff helps select topics, recruits expert panelists, arranges study visits to foreign laboratories, organizes workshop presentations, and finally, edits and disseminates the final reports.

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Draft Report

March 2005

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## **ABSTRACT**

[Abstract to be placed here]

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## FOREWORD

We have come to know that our ability to survive and grow as a nation to a very large degree depends upon our scientific progress. Moreover, it is not enough simply to keep abreast of the rest of the world in scientific matters. We must maintain our leadership.<sup>1</sup>

President Harry Truman spoke those words in 1950, in the aftermath of World War II and in the midst of the Cold War. Indeed, the scientific and engineering leadership of the United States and its allies in the twentieth century played key roles in the successful outcomes of both World War II and the Cold War, sparing the world the twin horrors of fascism and totalitarian communism, and fueling the economic prosperity that followed. Today, as the United States and its allies once again find themselves at war, President Truman's words ring as true as they did a half-century ago. The goal set out in the Truman Administration of maintaining leadership in science has remained the policy of the U.S. Government to this day: Dr. John Marburger, the Director of the Office of Science and Technology (OSTP) in the Executive Office of the President made remarks to that effect during his confirmation hearings in October 2001.<sup>2</sup>

The United States needs metrics for measuring its success in meeting this goal of maintaining leadership in science and technology. That is one of the reasons that the National Science Foundation (NSF) and many other agencies of the U.S. Government have supported the World Technology Evaluation Center (WTEC) and its predecessor programs for the past 20 years. While other programs have attempted to measure the international competitiveness of U.S. research by comparing funding amounts, publication statistics, or patent activity, WTEC has been the most significant public domain effort in the U.S. Government to use peer review to evaluate the status of U.S. efforts in comparison to those abroad. Since 1983, WTEC has conducted over 50 such assessments in a wide variety of fields, from advanced computing to nanoscience and technology to biotechnology.

The results have been extremely useful to NSF and other agencies in evaluating ongoing research programs, and in setting objectives for the future. WTEC studies also have been important in establishing new lines of communication and identifying opportunities for cooperation between U.S. researchers and their colleagues abroad, thus helping to accelerate the progress of science and technology generally within the international community. WTEC is an excellent example of cooperation and coordination among the many agencies of the U.S. Government that are involved in funding research and development: almost every WTEC study has been supported by a coalition of agencies with interests related to the particular subject at hand.

As President Truman said over 50 years ago, our very survival depends upon continued leadership in science and technology. WTEC plays a key role in determining whether the United States is meeting that challenge, and in promoting that leadership.

Michael Reischman  
Deputy Assistant Director for Engineering  
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<sup>1</sup> Remarks by the President on May 10, 1950, on the occasion of the signing of the law that created the National Science Foundation. *Public Papers of the Presidents* 120: p. 338.

<sup>2</sup> Statement of Dr. John H. Marburger III before the U.S. Senate, [http://www.ostp.gov/html/01\\_1012.html](http://www.ostp.gov/html/01_1012.html).



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# CHAPTER 1

## INTRODUCTION

**Ronald L. Rardin**

Research on a vast array of fronts has produced rapid advances in medical diagnosis and imaging, and on interventions of every form including miraculous pharmaceuticals. Their combined effect has been enormous improvements in the length and quality of life for citizens in many nations. Still, each such tool poses a host of delivery questions: Where to use it? Who will use it? How often to use it? What patients should receive it? What clinical process should be employed? How should that process be planned and scheduled? How much will it cost? Who will pay the cost? How will quality and safety be maintained? There are many more.

Those delivery questions and what the tools of the field of Operations Research (OR) may be able to do in addressing them are the subject of this cross-national technology investigation. Under sponsorship of the National Science Foundation (NSF), the Agency for Health Care Research and Quality (AHRQ), and the National Cancer Institute (NCI), the World Technology Evaluation Center (WTEC) organized a panel of experts to visit a number of Western European nations in November, 2003, and gather information about how OR activity is being conducted and applied to health care delivery challenges in those countries. The goal was to inform decision makers in the United States about trends and opportunities in the field.

The panel was chaired by Professor François Sainfort of the Georgia Institute of Technology. Other members were Professor John Blake of Dalhousie University in Nova Scotia, Professor Diwakar Gupta of the University of Minnesota, and Professor Ronald Rardin of Purdue University. Professor Michael Carter of the University of Toronto also assisted in several parts of the investigation, although he was not able to make the visits. Professor Janet Twomey, then project Program Manager for NSF, accompanied the panel in its onsite visit phase as did WTEC staff and contractors.

As detailed in later chapters and the appendices, the panel visited with leaders of operations research and systems science investigation in the United Kingdom, the Netherlands, Germany, Austria and France. Panelists familiar with circumstances in Canada also added that nation to many of the discussions although there was no formal visit.

### **HEALTH CARE CHALLENGE**

All the countries visited, and indeed most of the World faces the enormous task of making advances in health care available in a safe, efficient and equitable way at an affordable cost. Figure 1.1 shows how spending is surging in virtually all developed nations, both in absolute terms and as a percent of GDP. The growth relative to GDP is higher in the United States, but it is accelerating in many places. With the expectation of an ever growing array of valuable new health care treatment and imaging tools, improvements in delivery are the most promising way to address growing costs.

Costs are also far from the only concern in delivery system structuring. Breakdowns in information flow and continuity of care, which lead to inconsistent and sometimes unsafe patient services, are a challenge in all the countries visited. Although some exceptions were reported, most systems are also plagued by unacceptable delays in delivering needed patient services. These issues too demand intensive investigation.

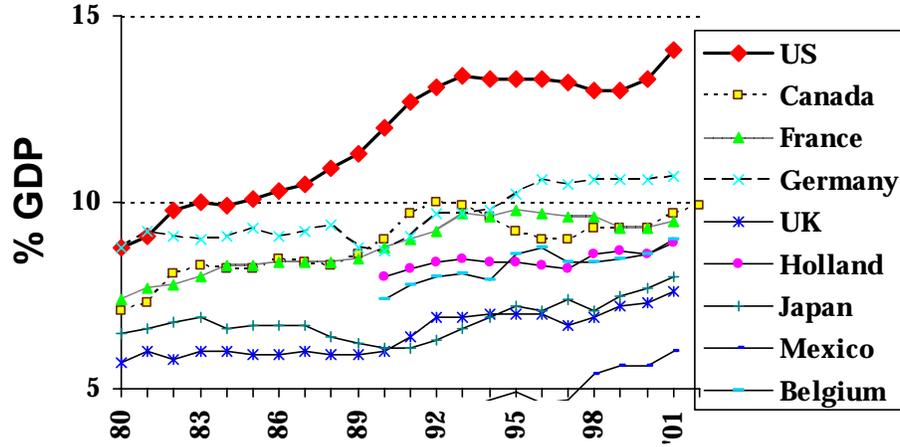


Figure 1.1: Health Spending as a Percentage of GDP

### NATIONAL SYSTEM DIFFERENCES

Figure 1.2 displays the enormous variation in per capita health care expenditures among developed nations. Values for many countries are less than half of that for the United States. Delivery and funding mechanisms may be part of the explanation. The countries studied in this investigation illustrate the variety of systems employed.

- United Kingdom health care has the most centralized history of those studied, with hospitals run by government-funded trusts. General practitioners are independent contractors paid with tax funds under contract.
- Germany uses mandatory health care insurance supplied by a collection of sickness funds; half is paid by employees and half comes from employers. Hospitals and General Practitioners are independent contractors to sickness funds. Hospital capital spending is supported by taxation.
- Austria employs mandatory health care insurance supplied social insurance funds operating much like Germany's sickness funds. Hospitals are financed by the Lander (states).
- The Netherlands has compulsory insurance for lower income citizens but it is voluntary for higher incomes. Insurance revenues go into a central fund and then are paid to hospitals and GPs.
- France has basic insurance paid by taxation and employers with voluntary options to enhance. Global budgets for hospitals are regulated.
- Canada employs a publicly financed but privately delivered system. All medically necessary services of doctors and hospitals are covered. Hospitals and physicians are private.

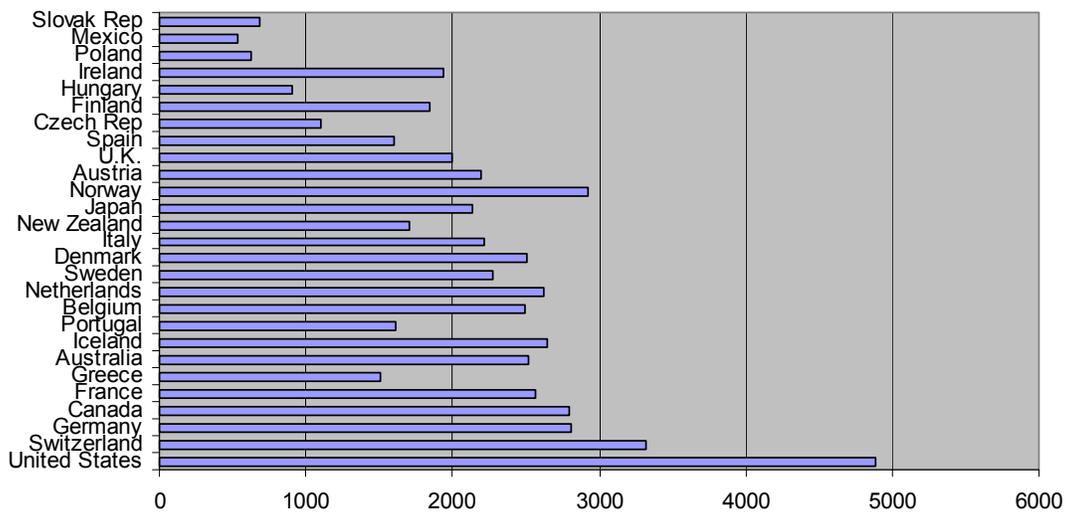


Figure 1.2: 2001 Health Expenditures per Capita in US\$

In spite of these significant differences, the chapters to follow document more similarities than distinctions in the issues of greatest interest to health care delivery researchers and the challenges they are trying to address. All are interested in continuity of care. All want to improve information systems. All seek to discover the best implementation region for each medical advance. All hope to reduce costs and delays.

## **OPERATIONS RESEARCH MODELING AND ANALYSIS**

Each health care operations design, planning or control problem raises a host of decision choices – what to do and how to do it effectively. Some are made only as the system is designed; others continue every day as operations adapt to patient demands and other conditions.

Research in most parts of health care is attuned to deciding such issues with randomized trials or pilot implementations. Formal experiments are designed and conducted in clinical or laboratory settings to see what approaches seem preferable.

These experimental approaches can produce valuable and evidence-based results on broad medical questions like what medication is effective and what diagnostic tests are justified. But they are usually far too slow and expensive to address the many details of health care delivery operations. Effective service requires efficient, reliable and sustainable delivery processes. Even if the broad outline of a successful program is known, some planning and control decisions need to be confronted daily, often in high volumes, and they have a powerful effect on cost, quality and patient satisfaction.

Operations Research (other names that are essentially synonymous in the health care delivery context are management science, operations management, and industrial engineering) employs a predictive modeling investigative paradigm that is not very familiar to most health care professionals although it is common in many manufacturing and service industries. Mathematical equations, computer logic and related tools are used to forecast/predict the consequences of particular decision choices without actually implementing them. Some such models can be represented in a simple computer spreadsheet; others require the fastest super computers. All of them permit alternative choices to be evaluated and compared to see which are most likely to produce preferred outcomes – and to do so within the computations of the model rather than any actual implementation. In the best of cases, the user can systematically search for the best or optimal choices.

To illustrate, consider the design and operation of a diabetes management program. The preferred treatment regime of diagnostic tests, medication, etc. necessarily comes from experimentation and evidence-based medicine. But these alone do not describe a full implementation plan. How will smooth information flow among service providers in the program be established? How much capacity at various facilities is needed to provide the required services and how should it be adjusted from day-to-day with variation in demand? How much delay will patients experience in the process? What mechanisms will be established to assure compliance and patient safety? What will be the cost with different options?

It is these implementation specifics of health care operations where operations research modeling can be most beneficial. A suitable mathematical representation of the delivery program, controlled parametrically by decision choices, can permit an engineer or analyst to investigate an enormous number of options in a relatively brief time and assess their consequences to evolve a preferred choice. The result will be fast and low-cost decision making, unhindered by ethical limits constraining tests on real patients, which can avoid bad choices and tragic consequences before a system is implemented.

Researchers in the OR field devote their energies to discovering and implementing better and better mathematical tools for addressing relevant health care delivery issues. To be useful, models must have high validity in yielding results and predictions that are trustworthy enough to be implemented in real operations. At the same time, the models must also have high tractability or convenience for analysis; otherwise, they will not produce any useful conclusions within the time available for decision making. The researcher's challenge is to balance these considerations to develop and disseminate tools that can truly inform health care system design and operation.

## **THIS BOOK**

The remainder of this book surveys what the investigative team found about the state of operations research and related investigation in the subject countries. What kinds of issues are being addressed with OR

approaches? What form do the models take? How is the research on these techniques funded? How successful has it been? We hope the results will be useful to decision makers in finding ways to increase the contribution of operations research and related fields to addressing the challenge of health care delivery.

## **CHAPTER 2**

# **TRENDS IN INFORMATION TECHNOLOGY AND CHRONIC DISEASE MANAGEMENT**

**John Blake**

### **INTRODUCTION**

In this chapter, we focus on the state of the art in Operations Research (OR) applications in information technology (IT) and chronic disease management (CDM). The analysis is based upon a summary of findings from interviews conducted as part of the WTEC study. The results of this analysis suggest that while information technology is an important topic within all health care systems, it remains an area of sparse OR research. Chronic disease management is an area of active research in Europe, particularly within the context of a health technology assessment.

### **DEFINITION**

Information technology is the branch of technology concerned with the dissemination, processing, and storage of information, especially by means of computers. Chronic disease is defined as a long-time, long-continued, lingering, or inveterate disease state. Both IT and CDM are concepts in everyday use, but which encompass a range of more specific meanings. In common usage, information technology is assumed to include all the hardware, software, and organizational elements that comprise the gathering, storage, analysis, flow, and distribution of data and information within an organization. Chronic disease, which is often defined as the opposite of acute disease, is broadly assumed to refer to any disease with a long lead time or for which there is no effective treatment. Clearly, the coverage of such broad topics as IT and CDM is impossible within the confines of a short survey article. Accordingly, for the purposes of this chapter we will focus on the interaction between operations research and information technology and between operations research and chronic disease management within the health care system. Thus, for example, our survey includes the application of OR techniques to design an electronic health record (EHR), but excludes discussions of the hardware, software, or network architecture necessary to support one. Similarly, while our discussion includes OR techniques applied to design, develop, or improve the care systems devoted to patients suffering from chronic disease, it excludes discussions of the disease states themselves.

### **INFORMATION TECHNOLOGY: INTERVIEW RESULTS**

One of the more salient features of the WTEC interviews with European OR specialists is the lack of research in the field of IT design, optimization, and evaluation. Interviewees noted the penetration of IT in the broad sense within their local, regional, and national health care networks. While respondents noted IT sophistication and integration tended to be proportional to the size of a particular care system, all indicated that some level of IT was present. Nevertheless, IT penetration was described as neither complete, nor seamless, by respondents. Respondents noted a varying reliance upon paper records and corresponding barriers to integration raised by paper records within their systems. Few respondents declared an active interest in information technology; no respondent described it as their major focus.

### **Information Technology Environment**

U.K. respondents indicated wide variability in IT systems across different organizations within the National Health Service (NHS). While most Trusts<sup>3</sup> maintain computerized records, integration of records across facilities is not presently possible due to differing data structures and computer infrastructure. Furthermore, hospital records cannot be integrated with data from primary care physicians. Dr. Paul Harper noted that while many primary care physicians (GPs) do have computerized record systems, the lack of common standards for data storage and interchange prevents the electronic flow of data between GPs as well as between GPs and hospital facilities. In many cases, paper records are employed to transfer data between providers, such as when patients register with a new GP.

A similar situation was reported in Germany. Dr. Reinhard Busse indicated that most GPs have computers, which are used for billing, access to care guidelines, and in some cases, automatic generation of prescriptions. However, there are no centralized computer systems or standards for software in Germany. Thus, data integration between primary care physicians, sickness funds, and hospitals is limited.

Dr. Marion Rauner described the Austrian environment as similar to that in Germany. Physicians, sickness funds, and hospitals all have access to computerized record-keeping systems. However, since each of the nine counties in Austria has their own health care system, sickness funds, and reporting structure, there is no integrated data network in Austria. Dr. Rauner noted, like her U.K. counterparts, that the level of sophistication within a system is largely dependent on the size of the system and the sickness fund's market share; she noted, however, that at least one large sickness fund in Austria utilizes good information technology.

The environments in the Netherlands and France both display a similar pattern. Information technology components are widespread throughout the system, but are not standardized or networked. Dr. Jan Vissers indicated that while some linkages do exist in the Netherlands, inpatient, outpatient, and primary care data is not integrated, since individual providers maintain their own systems. Dr. Stephen Chick described the French environment as being similar. He noted that GPs and hospitals in France all have computer systems in place, but that very little integration is possible, since each provider is responsible for implementing their own record-keeping system. This yields some rather interesting observations. The Paris hospital system, with approximately 50 institutions, is Europe's largest single health network. Nevertheless, only one institution in the city has a system that could be described as "state-of-the art." France, however, does deploy smart cards (Carte Vitale) to its insured population. Smart cards contain basic demographic and insurance data about the patient and can be accessed throughout the French system. However, Dr. Chick feels that IT support for patients and consumers in France is still lacking. He noted that NHS in the U.K. provides substantial data on the Internet that allows patients to view wait lists, quality data, and some disease management information.

The sole exception to the trend in Western Europe was observed in Belgium. Dr. Luc Delesie noted that the Belgian government is interested in the concept of electronic patient records and indicated that basic information systems are now in place. Most physicians (~90%) have PCs and are able to collect and transmit data. He noted that automatic prescription generation, and requisition of, and feedback on, laboratory tests is common. As an example of information interchange, Dr. Delesie indicated that physicians are now able to view their patient's radiology results online. Dr. Delesie indicated that data interchange is possible within the Belgian system because of the influence of the National Insurance Agency and the emphasis on uniform medical records dictated by a number of professional groups. Data exchange is also possible between hospitals and between hospitals and GPs. Eighty percent of hospitals are able to send discharge notes to GPs via electronic means. Networks are currently being developed that will enable GPs to access full hospital records.

### **Consumer and Management Data**

Despite the lack of an integrated IT environment in any of the health care systems reviewed, European systems do collect data for management, financing, and quality control purposes. This information is

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<sup>3</sup> Public hospitals in the U.K., after reforms of the late 1980s, are managed by independent not-for-profit agencies called Trusts. The terms "Trusts" and "hospitals" are often used synonymously.

available, to a greater or lesser degree, to health care managers and consumers, as well as regulatory agencies.

The U.K., which has the most centralized health care organization of all the systems reviewed, collects, maintains, and distributes a relatively broad range of data for management and consumer purposes. (The U.K., for the purposes of this discussion, might be more correctly described as “England,” since independent health systems and management structures exist in Wales and Scotland. However, these systems are similar in nature to NHS in England.) The Department of Health keeps publicly available statistics on wait lists for admissions and treatment, broken down by specialty and hospital. High-level health system performance metrics (death rates, admissions, costs, etc.) broken down by county level are also broadly available as are statistics on a variety of health, social, and public health programs. It is possible, for instance, to view online statistics as specific as the number of patients in the U.K. receiving electro-convulsive shock therapy. A number of policy, planning, and management documents for particular diseases or disease treatment strategies are available as well.

U.K. respondents, while noting the value of providing consumers and managers with data to make informed choices, suggested that aggregate data is not always clinically meaningful, nor is it always suitable for intra-agency comparisons. U.K. respondents stated that hospital data is often incomplete and therefore not useful for clinical purposes, such as evaluating the efficacy of treatment options for chronic diseases. Furthermore, even management data may be suspect. Dr. Ruth Davies argues that management data is sometimes presented and reported in a manner that sheds the best possible light on the reporting Trust. This makes comparisons across Trusts fraught with difficulty. Nevertheless, another U.K. respondent (Dr. David Worthington) provided an example of research making use of nationally available datasets to identify Trusts with good (or bad) wait lists.

The Austrian system, which is smaller than the U.K. system and somewhat more decentralized, also maintains a national dataset for quality control and management purposes. Dr. Rauner indicated that documentation and data collection processes are universal and are considered to be good. ICD-9 and/or ICD-10 coding schemes are in place for both inpatient and outpatient procedures, though some discrepancies exist between GP and hospital coding. Cost data, however, is not collected; determining the marginal costs for care in the Austrian system is not presently possible.

The German system, which has a diverse organizational structure, does maintain some aggregate data for planning and quality control. Dr. Busse suggested, however, that aggregate data in the German system tends to be less than ideal. He related an experience from a recent study where it had been impossible to determine ownership status of a hospital from the centrally available registry. Dr. Busse also noted that aggregate clinical and management data is collected and analyzed, but not by a central agency; individual sickness funds collect and monitor this data.

The Dutch system employs Prismant, a third party, non-profit firm, to collect, analyse, and distribute aggregate planning data. Prismant collects and processes data on the use of health services. It conducts annual surveys on topics such as resources, personnel, and finances. In addition, Prismant also serves as the central repository for inpatient discharge summaries. It conducts applied research surrounding operations methods as well as developing tools for improving quality and efficiency. Prismant also undertakes consultancy work, such as studies to implement a programmatic-based treatment of mental health clients and the optimization of operating theatres. Prismant disseminates study findings through workshops and educational programs, as well as through electronic and print publication. Some data on wait lists for selected inpatient hospital procedures and other performance indicators is also collected by the Dutch Ministry of Health and made available to consumers via the web; Dutch efforts in consumer information are largely designed to enhance consumer empowerment.

The situation in France was described as similar to the Netherlands. Dr. Chick noted that aggregate data is available to consumers, but tends to be incomplete, due to the decentralized nature of IT planning in France. While insured persons have smart cards available to them and are able to access some disease information, quality control data and data for managing the overall system remains an issue. France, for example, has no equivalent of the Health Care Financing Administration (HCFA) data available in the U.S.

### **The Electronic Health Record (EHR)**

The electronic health record is a highly anticipated element in most health systems. It has long been recognized that traditional record keeping in health care is ponderous, expensive, and disjointed. In many health care systems throughout the world, records are kept and maintained by multiple providers, in multiple locations, in a wide variety of formats. A patient may have a record maintained by a general practitioner, another maintained by an inpatient facility, and yet another maintained by a specialist. Since patients are mobile, the list of health care providers maintaining a file on a patient over his or her lifetime can be quite numerous. In the past, patient records were largely paper-based and thus impossible to integrate. However, as individual providers move away from paper systems to electronic record keeping, the tantalizing possibility of a single, integrated, record for patients arises. An integrated electronic health record<sup>4</sup> offers a number of potential benefits. Health Canada (2001) defines these benefits as:

- Enhanced patient care and improved quality of care
- Increased productivity of health care professionals
- Reduced administrative costs
- Enhanced support for health services research
- Support for future developments in health care technology, management, and finance
- Enhanced patient confidentiality

It has also been long realized that there are substantial barriers to the development of electronic health records. The decentralized nature of health care delivery in many jurisdictions means that different levels of government, disparate professional associations, and numerous public agencies and private firms have overlapping, and occasionally conflicting, interests. The large number of stakeholders involved in health care makes development of appropriate standards difficult. The volume of providers also makes the process of developing an integrated health network very expensive. Even technical questions, such as the mechanisms by which messages are transmitted, and the logistics of scalability and network infrastructure, have hampered the development of EHR. Throughout Western Europe where health care is to some degree publicly financed, it is assumed that government policy and funding is a necessary precursor to widespread EHR adoption.

To date, there have been a number of programs in the U.S., Canada, and Europe that have attempted to develop some component of an EHR or to pilot an EHR within a small geographic region, but no broadly based, comprehensive, or universal system is presently in place (Health Canada, 2001). Survey respondents echoed this view. All respondents noted that electronic health records are “on the horizon” and are of interest to their national, regional, or local health systems. Curiously, few respondents described the EHR as an important area for their research, despite the obvious benefits that the existence of an EHR would have on the ability to conduct OR studies, particularly for health technology assessment.

Five of the six respondents from the U.K. described health technology assessment as a major research focus; all noted the impact of data availability on their research agendas. Dr. Steven Gallivan indicated that the long time frame involved in chronic diseases and the lack of a central patient registry makes it very difficult to judge the quality of treatment plans. Only one of the U.K. respondents, Dr. Sally Brailsford, indicated a research interest in electronic health records. Dr. Brailsford has been working with the Ministry of Defence (MoD) to develop an electronic patient record for members of the armed services. Since the MoD system will interface with the NHS system, she believes this work may be able to serve as a template for EHR development in the civilian sector. U.K. respondents opined that NHS initiatives to develop an EHR are behind schedule and are likely to be less comprehensive than originally envisioned.

The respondent from Germany, Dr. Busse, also described health technology assessment as a major research focus. Like the U.K. respondents, Dr. Busse feels that a lack of a centralized patient record impedes technology assessment, quality control, and the implementation of evidence-based medicine. He stressed the need for longitudinal outcome-oriented data for treatment and management of chronic diseases such as

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<sup>4</sup> A number of authors differentiate between the concept of an electronic patient record (EPR) and the electronic health record (EHR). The EPR is a record maintained by a single provider. An EHR is composed of the integrated EPRs of a number of providers that may also contain administrative and utilization data.

diabetes and breast cancer. Dr. Busse suggested that the introduction of an EHR in Germany is a logical next step and believes system designers can build on existing smart card technology. At present, since U.S.-style discharge datasets are not available, targeted, manual data collection remains a necessity for OR studies. Dr. Busse did not indicate any research interest in the development of an EHR. He did suggest a research interest in evaluating the effectiveness of the technology, once it becomes available.

Respondents from the Benelux region described a similar situation. Dutch respondents describe technology assessment as a major element of either their research agendas (Dr. Rutten) or of the research community in their country (Dr. Vissers). Again, Dutch respondents noted the difficulty of conducting longitudinal studies without integrated data, but indicated no research interest in EHR<sup>5</sup>. The Belgian respondent, Dr. Delesie, did not indicate a research interest in Health Technology Assessment (HTA). However, Dr. Delesie noted the recent development of HTA in the Belgian research community and the ongoing interest of the Belgian government in developing electronic patient records.

Respondents from France reported a situation similar to other Western European countries. Dr. Chick, whose research includes both applications and methods in technology assessment and disease screening studies, echoed the opinion that the lack of integrated data records hampers effective evaluation of medical procedures, drugs, and technologies.

## **OPERATIONS RESEARCH IN IT**

Of particular note in interviews with European researchers was the preponderance of activity in the areas of health technology and disease management. The rationale for the European focus on HTA is described fully in Chapter 3, but can be summarized as a function of the degree of public participation in the health care system; the desire to obtain the best use of public funds in a very costly budget area; and a research promotion and funding structure that favors HTA research.

Despite the importance of HTA within the research agendas of the European respondents, a number of studies within the area of IT were noted during interviews. This research can be broadly categorized as: technology evaluation, continuity of care, telemedicine, strategic planning, and decision support systems.

### **Technology Assessment**

Given the preponderance of HTA in the research agendas of the European respondents, it is not surprising that a central theme of IT-related research has become the evaluation of new information technology developments. The U.K. has an established history of applying technology assessment techniques to new information systems. The Clinical Operational Research Unit (CORU) at the University College of London has published a number of policy studies on IT. During the London interviews, Dr. Gallivan highlighted his experience with an example of a telemedicine project in Deptford (a district in London) that had been set up to handle women's health issues. U.K. respondents, however, also noted an incomplete penetration of assessment techniques with respect to information technology projects. Dr. Gallivan suggested that historically money has been spent on IT systems without full technology assessment. As a result, some IT projects have proven to be less effective than might have been otherwise hoped for.

European respondents were keen to note the importance of, and research potential for, HTA assessment of future IT projects. Respondents noted that as large, complex, and potentially expensive EHR programs come online, the need for clear evaluation of IT costs and benefits will become a major focus for European HTA research. U.K., German, and French respondents all presume health technology assessment activity will develop as funding for EHR grows.

### **Continuity of Care**

Applications of IT to promote continuity of care are an area of research interest for European respondents. The Dutch respondents are particularly interested in using information technology to improve the flow and care of patients suffering from strokes. Dr. Vissers described a project to develop a seamless program of care for stroke patients in which information technology will be used to optimize the flow of information

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<sup>5</sup> Dr. Vissers described a study in stroke treatment assessment requiring longitudinal data. To get this data, a web site was created. Study participants at different locations were required to manually key in patient data so that a longitudinal dataset could be created.

between providers. Research opportunities exist for the creation of future integrated data systems to transfer information and also in the area of data mining to extract a relevant flow of information from existing, disparate data sources.

### **Telehealth**

A number of respondents indicated research potential in the area of telehealth. Telehealth applications were noted primarily in the U.K. and Belgium. U.K. respondents described a number of active telehealth applications, including the NHS Direct program. The NHS Direct program is a 24-hour hotline and Internet health service designed to provide a simple triage mechanism to allow patients to determine if they need to access an emergency room. Respondents at INSEAD (Chick, Gilmartin), who have exposure to health systems in a number of European countries, noted that telehealth applications are being actively pursued by Welsh health authorities as a mechanism for bringing health care services to rural populations. In one Welsh application, IT is being used to transmit diagnostic imaging results to radiologists at tertiary treatment centers (primarily London) for evaluation. A second application uses mobile health units, combined with IT resources to foster communication between rural practitioners and distant specialists.

The Belgian respondent, Dr. Delesie, has an active interest in nursing applications and has published several papers on information technology in nursing practice, including papers on telenursing for elderly patients and telematics technology for clinical and resource management in oncology care.

Respondents from INSEAD noted the potential for IT applications in unique areas. As an example, Dr. Mattia Gilmartin described devices manufactured by Health Hero, an American firm. Health Hero provides hardware (a simple communication device with a small LCD screen) for data collection and communication with patients. The system allows a single provider to monitor a large number of patients remotely. Dr. Gilmartin indicated that this type of application, which might have been difficult to predict several years ago, points to the vast potential for tele-medicine.

### **Decision Support Systems**

Respondents did indicate research activity and interest in the development of information systems to support clinical and administrative decision making.

U.K. respondents Drs. Harper and Davies both suggested the need for advanced administrative planning tools. Dr. Harper described present strategic planning tools as crude and suggested that a research agenda could be centered on improving tools used for strategic planning. Dr. Ruth Davies believes that policy and planning are often backwards; a policy is announced and only after the fact is an analysis done to determine whether or not the policy is effective. As an example, Dr. Davies noted that purchasing and planning decisions had devolved from the U.K. Department of Health to Primary Care Trusts without ensuring that the Trusts had the expertise or the tools to make appropriate allocation decisions. Dr. Martin Utley described a current project to develop a computerized system for determining anti-coagulant dosage in patients with heart conditions. Dr. Gallivan has published a number of papers dealing with decision support including a system for scheduling medical lectures in hospitals. There was a general consensus amongst respondents at the London meeting that large-scale decision support models, similar to the types of planning models in use by the Treasury Board to test economic policy, are feasible for health care and should be developed.

Several practical examples of decision support systems already in place were presented by Dr. Worthington. He described recent projects to create decision support systems for planning purposes: one model uses nationally available data to identify Trusts with good (or bad) wait lists; the second involves the use of a GIS system to help Primary Care Trusts identify health care needs within their region.

### **Strategic Planning**

Respondents from INSEAD indicated an active interest in strategic planning. INSEAD sponsors a series of interactions between health care managers, IT and device manufacturers, pharmaceutical companies, and academics. Of note is the Health care Management Institute (HMI), a research institute designed to support management research and knowledge transfer. HMI conducts management research, hosts seminars and executive training, and provides MBA course work. HMI also hosted the Health care 2020 forum, a strategic planning exercise to forecast the state of the health care industry in 20 years time.

### **Information Technology Summary**

Interviews with respondents from Europe suggest a consistent pattern. IT is seen as a critical resource for OR studies. Respondents all noted that while IT resources are broadly available within their health care systems, an integrated IT network has not evolved in any jurisdiction. Respondents universally believe that the advent of an EHR will allow significant advances within the OR research agenda and all respondents believe that an integrated IT network will emerge. Nevertheless, IT remains an area of little active research for respondents. This lack of interest may be due to the fact that respondents see IT as an application of known principles rather than an area of innovative research, or it may be due to funding systems that place significant focus on health technology assessment. The result, however, is that the OR community is largely absent from the design and development of technology infrastructure that will have a revolutionary effect on its research potential and direction.

### **CHRONIC DISEASE MANAGEMENT**

Chronic diseases are characterized as having an uncertain etiology, multiple risk factors, long latency, prolonged affliction, a non-infectious origin, and can be associated with impairments or functional disability. Examples of chronic disease include cardiovascular diseases (heart disease and stroke), cancer, diabetes, arthritis, asthma, and mental illness (Health Canada, 2004).

Chronic diseases have been identified as major drivers of health care expenditures. Health Canada estimates that approximately 67% of all direct health expenditures in Canada are due to chronic illness. The World Health Organization (WHO) (2003) estimates that more than half of the global burden of disease is due to chronic conditions. In developed countries, non-communicable diseases account for 80% of the burden of disease and account for 9 out of every 10 deaths in persons 59+ years of age.

Although chronic diseases are among the most common and costly health problems facing health systems, they are also among the most preventable. A variety of personal (diet, activity level, smoking status) and environmental factors (socio-economic status, access to housing, climate and culture) contribute to an individual's risk of chronic disease. Given the substantial cost of chronic disease and the aging population in developed countries, many health systems are actively seeking ways of preventing and managing chronic disease.

#### **Chronic Disease Management: Interview Results**

Interview respondents reported a research interest in chronic disease management. Amongst all respondents, interest in chronic disease management was significant. Overall, respondents described their interest within the context of health technology assessment, but since that is described in more detail in Chapter 3, this chapter will provide only a brief survey of CDM activities described during the interview process.

Reported research in chronic disease management can be broadly classified as either screening or protocol efficacy. A substantial proportion of the research work in CDM described by interview respondents involves the development, validation, or cost-effectiveness of tests to screen for the presence of a chronic condition or a marker indicating a risk for a chronic disease. A second area of research interest in CDM involves the evaluation of a treatment protocol or the comparison of competing protocols. A smaller body of work is dedicated to operational processes to improve patient flow, or to coordinate information exchange between professionals within a network devoted to chronic disease management.

#### *Screening*

Screening is a process by which an unrecognized disease or defect is identified by a test that is capable of identifying a healthy individual from an individual that likely has the disease. Screening is usually applied in instances where a disease has serious repercussions in terms of disability, discomfort, or death, a clearly defined pre-clinical stage, a well-understood natural history, and a long latency period. Ideally, a screening test provides information at a stage in disease progression at which point an intervention can be effective in halting disease progression or limiting its impact.

Screening tests, however, are not without difficulties. To be effective, a screening test must be sensitive and specific. It must correctly identify those individuals with a particular condition (sensitive) and it must correctly identify those individuals who do not have the condition (specific). In addition, because

screening tests are usually applied to a wide population, screening tests must be simple, inexpensive, safe, and socially acceptable. Finally, screening tests must be cost-effective; screening must provide society with treatment options that are less expensive than simply waiting for the disease to manifest. There is a great deal of interest amongst financiers of health care (governments and public or private insurers) to develop screening tests that are cost-effective because of the large potential pay-off arising from a hopefully modest investment.

In interviews with European respondents, a substantial research effort in the development and evaluation of screening processes was noted. CORU at the University College of London is active in this field. It has a wealth of published papers on the subject of screening, including studies in arthritis, cervical cancer screening, and Marfan syndrome.

Steven Gallivan has applied stochastic models to test the effectiveness of antenatal screening for Down's syndrome. He also has a long-standing interest in the efficacy of cervical cancer screening in developed and developing countries. His present work involves screening tests for Marfan syndrome and asymptomatic left ventricular failure, both of which are heart conditions. In these instances, Dr. Gallivan is employing discrete event simulation, decision trees, and semi-Markov chains to analyze screening efficacy. Dr. Martin Utley's research also involves analysis of screening options for chronic diseases, including Down's syndrome and rheumatoid arthritis.

Respondents from the University of Southampton and the University of Warwick described chronic disease screening as a major interest. Dr. Sally Brailsford is actively involved in diabetes screening projects. Dr. Ruth Davies, who has recently moved to Warwick from Southampton, also has a strong interest in chronic disease screening. Dr. Davies uses discrete event simulation to model the activities of patients over time and has applied this technique to conditions such as diabetes and chronic heart disease. Dr. David Worthington, from the University of Keele, has recently completed a study using a Bayesian approach to identify the value of perfect information for screening programs.

Dutch respondents did not cite any specific screening studies in the area of chronic disease management during interviews, but did note the creation of the Institute for Medical Technology Assessment (IMTA) at Erasmus University. IMTA is a group of 25 staff members who evaluate new interventions, such as screening plans, drugs, or therapies, before they are introduced into the Dutch health care system. The group conducts research under contract for governments, pharmaceutical companies, and device manufacturers. IMTA mirrors efforts in other European countries to create a central HTA authority for new, incoming technologies.

French respondents cited a number of developments in disease screening. Dr. Steven Chick is presently conducting research into the use of dynamic systems concepts to model patient flows. This research incorporates many smaller models into a single, large dynamic model. It will inform decisions on a number of issues, including the efficacy of screening standards. Dr. Chick suggests that the model will be useful for determining a minimum number of screens, identifying required levels of screening efficiency, or suggesting the best methods for making screening tests available to a population group.

#### *Protocol Efficiency*

Closely related to efforts to develop screening tests for chronic diseases are efforts aimed at determining optimal treatment protocols for chronic diseases. As is the case for screening, protocol efficacy research reported by respondents is generally framed within the context of health technology assessment.

Most U.K. respondents described their research as encompassing protocol efficiency studies, either in whole or in part. Drs. Gallivan and Utley described projects related to Marfan syndrome, cervical cancer, and congenital heart conditions. Dr. Brailsford is interested in diabetes and HIV/AIDS models, including a current interest in vertical (mother-child) transmission vectors for AIDS. Dr. Davies' research encompasses diabetes, renal disease, and coronary heart disease. Dr. Paul Harper's research includes evaluation of treatment options for breast cancer, diabetic retinopathy, HIV/AIDS, and colorectal cancer.

Dr. Reinhard Busse described an active interest in chronic disease management amongst German researchers. Dr. Busse's work, in which HTA is a predominant component, includes research into a variety of chronic diseases, including breast cancer, coronary heart disease, and evaluation of the efficacy of disease management approaches for chronic diseases. In addition to applications of HTA, Dr. Busse is also active in methodological developments and comparisons of HTA techniques.

Dr. Marion Rauner indicated a strong interest in HTA assessment of chronic diseases, which is mirrored by other members of the Austrian OR community. Dr. Rauner's work includes HIV/AIDS policy modeling, HIV transmission vectors, diabetic foot syndrome, coronary heart disease, and vaccination policies. Other Austrian studies include depression (Hofmarcher), breast cancer, colorectal cancer and ovarian cancer (Jonas), coronary heart disease, Alzheimer's, assistive devices for elderly patients (Wild), and hypertension (Heidenberger).

Respondents from INSEAD also describe an active program of research in HTA as applied to chronic disease. Dr. Gilmartin has worked with several NHS Trusts to evaluate treatment protocols for chronic diseases, especially diabetes, and is currently working with a manufacturer to determine the efficacy of a device to resynchronize ventricles in patients suffering heart failure. Dr. Chick, who works primarily in infectious diseases, has also conducted a number of studies on chronic disease, particularly breast cancer.

Dutch respondents noted an active program in HTA in the Netherlands. Frans Rutten, who founded the IMTA and was its managing director, has conducted a wide range of HTA studies including studies in chronic diseases. Examples of Dr. Rutten's work include infertility, psoriasis, Alzheimer's disease, benign prostatic obstruction, hypopituitarism, erectile dysfunction, colorectal cancer, spinal cord injury, and evaluation of home care services.

#### *Operational Issues*

In addition to HTA-based screening and treatment protocol research, respondents described a number of studies focusing on operational issues in chronic disease management.

Dr. Vissers described a recent project to develop a seamless continuum of care for patients who have suffered strokes. The project involves improving the flow of information between providers and determining the optimal mechanism for managing disease across the care spectrum. Dr. Vissers describes the project as organized around a medical approach, rather than an operational research or operations management approach. Nevertheless, a pilot project was initiated in Delft that yielded promising results and is being promoted as a model for reform within the Dutch system.

French respondents described projects in home care optimization. Dr. Yves Dallery from the École Centrale in Paris is initiating a project to evaluate the potential for expanding home care services in France.

Dr. Delesie described an application of OR techniques to develop appropriate funding mechanisms for chronic care and mental health facilities in Belgium. His interest in this area is centered on determining performance metrics, via consensus, that are acceptable to all stakeholders. Work on the mental health model is still in the preliminary stages.

## **SUMMARY**

Chronic disease management was found to be a significant part of the research agendas of survey respondents. Applications in both the development of screening tests for chronic disease and the development and comparison of treatment alternatives are apparent. Chronic disease studies are frequently framed within the context of HTA. A smaller number of studies focus on the operational aspects of chronic care, such as improving patient flow or coordinating data exchange between providers.

We speculate that the health care systems (and by extension the health research funding structures) in Europe emphasize cost containment and thus tend to support researchers who are interested in HTA-type studies. This is particularly true in smaller countries without native pharmaceutical or device manufacturing industries, such as the Netherlands or Belgium, or in countries with more centralized health care systems, such as the U.K.

A number of respondents indicated that research agendas tend to follow funding opportunities. Thus, the OR health care community in Europe finds it necessary to carve out a niche for itself within the framework of health technology assessment. The structural differences in funding between the U.S. and Europe thus give rise to different research agendas within the OR communities.

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## CHAPTER 3

# CAPACITY PLANNING AND PATIENT FLOW MANAGEMENT

**Diwakar Gupta**

### INTRODUCTION

Health care delivery systems are nearly universally organized according to the medical model. European countries surveyed in this study are no exception. In this arrangement, primary-care providers (known as general practitioners (GPs) or family doctors) exist either as independent entities, or in group practices. The latter are usually small with a few (e.g., three to four) doctors getting together to form a practice.

Secondary and tertiary care is provided in an institutional setting. These institutions are usually general hospitals, but could also be specialized hospitals/clinics focusing on one or a few medical specialties. Service delivery is typically compartmentalized according to the medical specialty, e.g., cardiac, orthopedic, and ophthalmic services. Within each medical specialty, services can be further divided into two categories: ambulatory and non-ambulatory. Other names for the same classification scheme are outpatient- and inpatient-care services. The latter classification is based on whether or not the needed procedure/treatment protocol requires a patient to be “admitted” to the institution for at least one night. Ambulatory cases include short procedures (e.g., day surgeries) and consultation visits to specialty clinics. In contrast, inpatients are usually those patients whose condition requires hospitalization for at least one night. Rehabilitative and social services (e.g., nursing homes, home care) are generally funded differently and may fall under a different government department, but they do overlap with the health care delivery systems in the countries surveyed.

Commensurate with the classification scheme described above, the provision of health care at the national level in the countries surveyed is often thought of in terms of the amount of health care spending on each segment of the health care system. Financial and provider resources also vary by the sector. Consider, for example, general practitioners. Their practices are housed in essentially office-like environments. Depending on the size of their practices, they may also employ nurses and/or medical assistants and an office manager. Cost of GP-office infrastructure is typically paid for by the GPs. Also, GPs belong to professional associations that negotiate compensation rates with the regional (sickness) funds and insurance companies. Total compensation is usually a mix of per-patient capitation fee and fee-for-service.

Typical GP offices maintain paper patient records, but often use computers for billing purposes. This is lately required by sickness funds in several countries surveyed. GPs usually act as gatekeepers to secondary and tertiary care systems. Patients are required to register with a particular GP practice, but they can choose any GP. In the U.K. and the Netherlands, there is a trend towards consolidation of GP practices from single doctor clinics to group practices.

In contrast, hospitals are typically financed by a combination of two types of funds: infrastructure funds that are provided irregularly to set up new facilities and/or upgrade existing facilities, and operating funds that can be based either on the number of beds, or on the patient volume, or on the number of episodes adjusted for severity of diagnosis, or a mix of these metrics. Hospitals are staffed by specialists (senior specialists are also called consultants), nurses, nursing assistants, medical assistants, and non-clinical support staff. Professional associations of different clinical staff negotiate compensation rates with the hospitals and the sickness funds. Most hospitals have their own patient-records database.

Typically, the in- and out-patient databases are separate and do not interact. In fact, there is little standardization in the type of data tracked, except when data pertains to billing requirements. Moreover, the GP-office patient records are not integrated with hospital records. Belgium appears to be an exception where data exchange between GPs and hospitals is possible.

In each country surveyed, hospital ownership is a mix of public and private, with the latter being both for profit and not-for-profit. In a majority of the cases, the privately held hospitals are not-for-profit entities. There is, however, a trend towards a greater number of privately owned hospitals. Furthermore, the number of procedures performed on an outpatient basis is increasing.

Turning now to the first of the two major issues being explored in this Chapter, capacity planning refers to estimating the need for each type of resource in the delivery system; for example, how many GPs, how many hospital beds, and how many nurses are needed to achieve a desired level of service. Service can be measured both in terms of operational measures like waiting times as well as in terms of medical outcomes and population health. Capacity planning also includes careful matching of the demand for medical services with supply by assigning priority to some patients and reserving capacity in advance for very ill patients. Thus, tracking and managing wait lists is an important component of overall capacity planning.

The second issue, patient flow management, refers to coordinative activities that focus on patients interactions with stand-alone providers, hospitals/clinics, and networks of service providers /clinics/hospitals. The focus of these activities is to ensure a smooth flow, i.e., minimizing communication and transfer-of-data problems as well as unnecessary delays for the patient, and ensuring that services are provided in the right sequence.

During our study of selected European countries, we asked our hosts specific questions relating to the broader aims of the study. We list these questions in Appendix B. This is followed in the State of the Art and Status of Research sections by a report on the information provided by our hosts. The State of the Art section describes the state of the art in capacity planning and patient flow management practices in each country and section three describes ongoing and planned research projects. This is followed in the Summary of Findings by a brief summary of our findings and concluding remarks.

### **THE STATE OF THE ART**

From the comments of researchers we interviewed, the following broad patterns can be identified. The health care systems in Austria, Germany, Belgium, and France appear to have ample capacity with the result that, for the most part, capacity planning methods are not under careful scrutiny by the research community. In fact, it appears that in these countries there is an oversupply of medical doctors and hospital beds. For example, our hosts from Germany and Austria told us that their countries chose not to participate in a recent OECD study on wait lists for health care on the grounds that there are no wait lists. In contrast, capacity shortages are a growing problem in the Netherlands and a serious problem in the U.K. Accordingly, we find greater emphasis in these countries on methodologies for matching demand and supply.

In all countries the universal health insurance system pays for a pre-specified list of diagnoses/treatments, which is often called the “benefits catalogue.” In recent years, there has been an increasing focus on cost containment which has led to careful scrutiny of what is covered by the benefits catalogue and for which patients. In fact, there is movement in several countries towards placing limits on which benefits patients qualify for and under what circumstances.

Patient flow management is considered a persistent and refractory problem by our colleagues in most countries surveyed. However, at the present time, the ability to perform such analyses is severely limited by the lack of data (with some exceptions in Austria and Belgium). In most countries, there is no link between ambulatory and non-ambulatory patient data, which makes it difficult to carry out studies that compare different patient populations. Most studies, therefore, pertain to comparisons of providers.

We turn now to the details for each country from which we had interviewees. In what follows, we devote a subsection to each country, in alphabetical order.

**Austria**

Health care in Austria is organized by county. There are nine counties served by different sickness funds with different hospitals and different reporting systems. Some of the sickness funds have good data on patient flow from GPs to hospitals; however, in general, patient flow is not tracked. One of the main sickness funds in Austria covers a large proportion (60—70%) of the population. Unfortunately, this data is not readily accessible to researchers. Capacity planning is carried out at the regional level. However, our interview did not reveal details of how this is done.

We have learnt that OR models have played some role in capacity planning. For example, models have been developed at the regional level to compare efficiency of different facilities (using Data Envelopment Analysis technique) and to help decide which facilities to keep open and which ones to close. In addition, there is interest in studying capacity planning for home care for the elderly. Different types of alternatives are being studied, including in-hospital care and financial incentives so that care can be provided by relatives at home.

The historical reimbursement system in Austria has resulted in an oversupply of hospital beds. Payment has been based on usage – higher usage leads to higher income for the hospitals. Since lengths of stay (LOS) are dropping, the oversupply situation has persisted.

**Belgium**

Capacity planning in Belgium is under the purview of different communities (French-, Dutch- and German-speaking communities) and regional authorities (Flanders, Wallonia and Brussels). These communities/regional authorities decide parameters such as the number and location of hospitals, the number of practicing physicians, and the number of funded seats in the professional (e.g., MD) training programs. Our interview did not reveal the extent to which OR techniques are used to determine these numbers. However, we have learnt that there is an oversupply of resources such as doctors and hospital beds. There are some shortages of community services for the elderly (e.g., homecare) and waits are not unknown for new and expensive treatments. But, by and large, capacity is seen as being more than adequate.

It appears that hospital and GP data systems are already integrated to a large extent in Belgium. Furthermore, all institutions are required to collect and contribute data to a national dataset. A unique patient identifier has existed since 1986. From these facts, it would appear that patient flow can be monitored and studied in Belgium. However, our interview did not uncover any specific studies.

**France**

Our interviews revealed that there is an overcapacity of GPs and hospital beds in France, but that at the present time, there is a shortage of nurses. The nurses' shortage is in part due to the 35-hour work week regulation in France. The shortage is estimated to be between 40,000 and 80,000 nurses. Our hosts did not describe how capacity planning is being carried out in France at a national and/or regional level, but gave several examples of their own research studies dealing with the pertinent issues. These are discussed in the Status of Research – France section. There is a high level of interest in studying patient flow, but such studies are limited by the lack of relevant data – GP practices are not linked to the hospital networks.

**Germany**

Similar to Austria and Belgium, regional German governments are responsible for determining the number of physicians and hospital beds needed. Each has its own rules to carry out this calculation, which are not required to be made public. As a consequence, our host could not comment on the precise method used to carry out capacity planning, but he suspects that international averages from selected countries (e.g., number of beds per 1000 population) are used as a benchmark and different regions adjust capacity from this base number according to rules that can vary from region to region. For ambulatory care, capacity calculations are adjusted from the de facto provision in the early 1990s, which is used to develop minimum and maximum number of medical services and physicians.

Over time, the benefits catalogue in Germany has become more specific and has included more restrictions, e.g., determining when a person may get a particular service. In addition, there are attempts to establish minimum and maximum service volumes for new medical equipment/procedures. The minimum volumes help to create scale economies, whereas the maximum volumes help to contain costs.

There is a great deal of interest in studying the efficiency and quality of service by tracking patient flow. The best sources of data for this purpose are the sickness funds. Different sickness funds have different reporting requirements and capture data to a different degree. At the present time, there is no link between the ambulatory and non-ambulatory sectors of the delivery system. Moreover, patient data is not tracked across sickness funds. For these reasons, it is difficult to do comparisons of service quality by patient groups.

### **The Netherlands**

The imbalance between demand and supply for health services is seen as an increasing problem in the Netherlands. Although wait lists are not as long as they are in the U.K., excessive waiting times are seen as a critical and often political issue. We learnt that in hospitals, beds are assigned to specialists and their numbers are calculated based on demographic information for each region. In nursing homes, beds are provided for on the basis of utilization. These two systems of providing capacity induce different types of provider behavior. Whereas it is possible to find empty beds in the hospitals, the nursing home beds are always fully occupied. In addition, we also came to know a number of interesting facts about the Dutch health care system. These are described in brief as follows.

The health care system in the Netherlands is in the process of transitioning from a regulated supply system to a demand-driven system. A major difficulty in realizing a good demand-driven system is achieving equitable distribution of resources. Health insurance premiums are income-based, which are then allocated to insurance companies through risk-adjusted premiums. Individuals do not buy medical services. Government manages competition in insurance and provider markets. Many changes have occurred in recent years, but the changes have not been implemented fully, resulting in a system that is a complex mix of public and private insurance companies. The current budget deficit is putting the brakes on the deregulation process, which limits insurance/provider competition.

Increasingly, consumers demand specialist services immediately. In that case, they bypass the GP and go directly to the hospital emergency room, increasing congestion. In order to provide better after-hours and weekend coverage, the GPs have organized to provide urgent-care services linked to the emergency department of hospitals. Usually, in a city there are one or two locations where urgent-care services are provided and a group of doctors are available for consultation on a rotation basis. GPs specialize in the care of chronic patients. Only 6% of GP contacts result in referrals to specialists. GPs do not own hospital beds, but use diagnostic services provided by the hospitals.

For-profit stand-alone specialist services are a fast-growing group within the health care delivery system; though they represent only 1–2% of services at the present time. Most specialists are affiliated with hospitals. Similarly, high-volume, high-efficiency service centers that focus only on certain limited types of procedures for less complicated cases (e.g., knee and hip replacement with no other co-morbidity factors) are also developing fast. This is similar in spirit to the development of diagnostic and treatment centers (DTCs) in the U.K. (see Status of Research – United Kingdom).

The health care provider market has seen a number of mergers lately which has reduced the number of players in the market. In effect, hospitals are growing in size and becoming service providers with several campuses and a comprehensive array of services. Hospital waiting times are tracked and can be found on the web at [www.nvz-ziekenhuizen.nl](http://www.nvz-ziekenhuizen.nl) (in Dutch). Hospital lengths of stay have been declining. Average LOS has dropped from 14 days in 1980 to 7.7 days in 2000. Same-day surgery performed on an outpatient basis accounts for about 40% of all surgeries performed.

Patient flow and capacity planning at the level of networks of providers/hospitals is not being carried out. Often the limiting factor is the availability of data. In addition, our hosts in the Netherlands felt that the organization of networks of service delivery in health care is not done from the Operations Management perspective. For example, in a recent reorganization of “stroke services,” a medical approach was followed. Efficiency of patient flow is not an important consideration in this effort.

### **United Kingdom**

The capacity planning and management of the health care delivery system is highly centralized in the U.K. The National Health Service (NHS) under the leadership of the Secretary of State for Health (a Cabinet Minister) sets annual expenditure levels – both for capital and operating expenses. Although NHS has gone through a series of restructuring initiatives, described in more detail in Chapter 2, it acts primarily as a

purchaser and regulator of medical services. The hospitals are run by NHS trusts, or simply Trusts, whereas regional (formerly district) Health Authorities (HAs) purchase services from hospitals and GPs. The general practitioners are organized in groups called primary care groups/trusts (PCGs/PCTs).

The central government, through the office of the Secretary of State for Health, also sets priorities for the development of a long-term service plan, which in turn help guide the local health improvement plans of individual HAs. Hospital capacity needs assessment is done by Trusts, some of which are known to use relatively simple, spreadsheet-based OR tools for understanding the relationship between capacity, demand and wait times (e.g., the Checklist software; details are available on the web at [www.checklist.co.uk](http://www.checklist.co.uk)). If a need for additional capacity is identified, then along with requests for capital funds, the Trusts have to submit commitments by HAs to purchase their services in order to be approved for additional capacity. This results in tight central control on overall system capacity and expenditure. Trusts are expected to maintain wait lists. Wait lists are published and Trusts can potentially lose funds if their list is too long. However, at present, no penalties are imposed for long wait times.

The medical workforce planning is done by an advisory committee. It develops a national strategic plan for workforce training and development. The Trusts are required to include information on medical staffing strategies in their business plans. Conduct of professionals, such as medical doctors, is regulated through the professional associations and regulatory bodies, which are also under the purview of NHS.

System-wide capacity planning activities occur within NHS, which has two OR groups of its own. In addition, there are OR groups within the Modernization Agency that are responsible for leading change in many of the U.K.'s social services, including NHS. We learnt that NHS frequently brings forward plans to address issues that reach a crisis level. However, the fundamental problem of a mismatch between supply and demand is almost never addressed. This can lead to odd results. For example, when capacity for a particular type of treatment is expanded latent demand appears and wait time does not appear to improve.

We learnt from our interviewees that in one such effort, NHS has, or will soon complete setting up, 48 Diagnostic and treatment centers in the U.K. Regionally based DTCs focusing on simple, routine elective cases (e.g., hip and knee replacements) without co-morbidities are envisaged. The goal is to bring down costs and reduce waiting time for non-urgent procedures by creating high-efficiency, high-volume treatment centers for routine cases. DTCs can either be a part of an existing Trust or can be set up as a Trust.

Another new development is the NHS Wait List Initiative. In London, this initiative is called the London Patient Choice Initiative. Under this program, if patients registered with one Trust wait more than six months for surgery, then they must be offered a choice. They can choose to either stay in the same queue or jump to a wait list of another region. The alternative queue may belong to another Trust, a DTC, a private clinic, or even a foreign hospital. Wait lists are published and Trusts can potentially lose funds if their list is too long. However, at present, no penalties are imposed for long wait times.

In pilot applications Trusts have not been penalized when patients move to another wait list, but the production version may include penalties. Thus, it is conceivable that some Trusts may act as patient donors to themselves. Furthermore, at present, the costs of monitoring, information gathering, and average transportation expense of about £50 per patient have been paid by the Department of Health through funding for the pilot project. It is not clear how these costs will be financed in the future. Thus, the full financial impact of the patient choice initiative is not well understood.

Studies of patient flows are constrained in the U.K. since hospital records are separate and disjointed, and there is no coordination of data between hospitals and GPs. In fact, we learnt that comparisons of patient data across health authorities are often difficult on account of lack of standard reporting methods. This leads to a situation where there is lots of data, but little information. On the positive side, GP notes are less of a problem in the U.K. since notes follow patients when they move from physician to physician (patients are required to register with a GP).

## **STATUS OF RESEARCH**

In France, Netherlands and U.K., there is considerable interest in capacity planning and patient flow management and many research projects are planned/currently underway. It is also worth pointing out that research efforts of INSEAD (France) faculty members are more international in nature. However, we found

fewer examples from Austria, Belgium and Germany. This is consistent with the fact that as a result of existing overcapacity, capacity planning methodology is not currently at the forefront of the research agenda of the academic community. We have categorized our findings below by country (once again in alphabetical order).

### **Austria**

As mentioned earlier, regional optimization and Data Envelope Analysis (DEA)-based benchmarking models have been used to examine such things as the opening and closing of facilities. Although capacity planning and patient flow are not the focus of Professor Rauner's research (our interviewee from Austria), she has plans to investigate data to understand patient flow and the impact of financial incentives on utilization of new technologies. She is also interested in service organization issues for the care of elderly. She mentioned that at the strategic level, Operations Researchers can help address many of the emerging issues in health care including:

- How should the different parts of the health care system be integrated?
- Will it be good to introduce managed-care plans in Austria?
- Should access to secondary and tertiary care providers be controlled through a GP-based gatekeeper system? In the current system, patients can access specialists without the need to obtain a referral from a GP.

### **Belgium**

Our primary contact from Belgium, Dr. Luc Delesie, worked for the Belgian Hospital Federation until 1993. In that role, his work involved strategy, planning, capacity, and financing. However, more recently, his research interest lies in the area of measurement – developing reliable measures of performance and indicators for health systems. This, together with the fact that major health care system resources appear to be oversupplied in Belgium, meant that we did not find examples of current research studies dealing with capacity planning and patient flow management. Dr. Delesie did mention some interesting facts about the state of the IT infrastructure in Belgium (see Chapter 2 for details), which suggest that studies of patient flow through networks of service providers should be possible. However, once again, we did not learn of such studies.

### **France**

There is active interest in capacity planning and patient flow management issues at INSEAD, where researchers' efforts often result in business cases being developed for teaching purposes. We learnt of several such examples.

- Professor James Teboul developed some cases based on a Swedish hospital (Ie Karolinska) that faced a shift from functional to Diagnosis Related Grouping (DRG)-based funding. This led to the hospital departments being reorganized on the basis of patient flows, rather than medical specialties. The case deals with operational and change management issues. It also points to the need for further research on the impact of DRG-type funding on quality, throughput and capacity planning.
- Another similar project is developing a strategic-level model of patient flows. The approach incorporates features of many different models into a single model. For instance, in the breast cancer area it looks at the quality of screening procedures, effect of the queuing times on treatments, and different standards for screening simultaneously in a common framework. The study compares French, U.K. and U.S. data for the interaction between test accuracy, quality and other aspects of breast screening/treatment.
- A third case deals with the consequences of poor capacity planning at a hospital in Leuven, Belgium. A patient, upon receiving a liver transplant, finds out that no ICU beds are available with the result that the patient is kept in the operating room for 12 hours. This incident sets off a snowball effect for capacity planning. The case describes how the scheduling of downstream resources should be coordinated with the scheduling of cases in the operating theatre. The case also talks about how to identify bottlenecks, how to manage physicians, and how to get system's thinking in place. It not only looks at flow of patients in one institution, but also at the flow of patients within a network of possible sites. The case study has resulted in the development of resource-scheduling software.

With regard to patient flow, colleagues at INSEAD are interested in studying how the availability of extra capacity in other EU-member nations affects reimbursement rates from local governments, and on problems of transnational patient flow management.

Dr. M. Gilmartin is working on a project in the U.K. on intermediate care facility planning. An intermediate care facility is run by specially-trained nurses (e.g., nurses trained to provide routine care for diabetes patients) and like the DTCs, its function is to lower costs and reduce the burden on doctors. The nurses can provide diet management, routine drug prescriptions and monitoring activities. Her research deals with planning and management of these facilities.

Dr. S. Chick, whose primary research area is epidemiology and public health has some projects that consider the interaction between capacity/resources and disease propagation and treatment strategies. Such studies could help drive health policy decisions. For example, leptospirosis, which is often caused by consuming untreated water, can lead to severe symptoms in immuno-compromised individuals. Disease can also spread when those individuals come in contact with those who are infected. Possible treatment strategies include revamping municipal water treatment systems to treat for leptospirosis or installing special filters on the taps of immuno-compromised individuals. This project models disease propagation under different treatment strategies to evaluate the cost-effectiveness of each alternative.

Professor Yves Dallery from École Centrale, Paris, is starting a project that will develop tools for operational planning for in-home delivery of certain types of services – e.g., palliative and prenatal care. The project will focus on questions related to cost-effective planning for providing such services. For example, if these patients need prescription drugs, how should drugs be delivered to patients? Should there be direct delivery from a local pharmacy? Should the delivery come directly from the hospital, or is it better to position warehouses that supply pharmaceuticals to patients in a region? What services are needed for palliative care of cancer patients? Which health care professionals and how many resources are needed? How should visits by medical professionals (MDs, nurses) be organized? The project has only recently begun and professor Dallery expects health care delivery research to be a major future research activity for him.

### **Germany**

Professor Busse described three levels of research where OR can play a role. These are (a) Macro (International/National) Level problems (b) Mezzo (Institutional) Level, and (c) Micro Level (a.k.a. Health Technology Assessment or HTA for short).

At the macro level, studies in health care need to focus on promoting entrepreneurial behavior, international health policy, the role of new technology, and IT in health care while simultaneously meeting regulatory needs. This includes issues such as the effect of slack capacity in some member nations after attempts to price health services uniformly across the European Union (EU).

Institutional level research refers to benchmarking various institutions on cost, quality and efficiency, and includes comparisons of disease management programs. These comparisons can be carried out across two dimensions – comparisons across patient groups who require services from a network of providers, and comparisons across providers. Professor Busse mentioned that at the present time, only the latter is feasible due to data availability issues. The ability to compare patient groups will help determine a network's relative performance in streamlining patient flow and minimizing unnecessary waits.

Lastly, HTA interacts with capacity planning in a significant way. For example, drawing up of contracts with the aim of preventing inappropriate usage of technology, along with regulation, ties in strongly with capacity needs assessment. Similarly, contracts that establish minimum service volume in order to realize scale efficiency and maximum total volume per unit of population impact capacity planning. Professor Busse mentioned that these issues are not currently being pursued in Germany but that there is hope that these will become prominent topics in the future as various decision making bodies (sickness funds, professional societies and regional governments) come together to think about an integrated system of delivering service to patients. Professor Busse's current research projects do not have a component of matching demand and capacity. He also mentioned that this is true of other researchers in Germany that he knows.

### **The Netherlands**

Dr. Jan Vissers is completing a book on health care operations management (OM), a publication of the Rutledge series on Health Management co-edited with Roger Beech of Keele University, which contains ideas from several of his articles on patient-flow logistics. Chapter 1 of his book presents the OM perspective and the need for managing processes; Chapter 2 deals with the establishing the requirements of a production planning and control approach to health care; Chapter 3 defines the operations, processes and approaches – the latter can have unit, chain or network orientation [The unit orientation is focused on hospital or medical-specialty clinic, the chain orientation considers all service providers along a chain linked by a common diagnosis, and the network orientation is patient-focused with possibly multiple symptoms and service needs.]; Chapter 4 is concerned with unit logistics and focuses on the optimal use of resources; Chapter 5 is concerned with chain logistics and focuses on optimizing the throughput of a chain; Chapter 6 is concerned with network logistics and here the focus changes to balancing service and efficiency to provide the appropriate quality of care. A case study-based approach is taken in the book to bring out the main issues in Chapters 3 to 6. The conceptual framework is presented in the first two chapters.

In Dr. Visser's opinion, the major challenge for health care operations management is that processes in delivery of health care are not managed. Such processes include coordination between different institutions, between ambulatory and non-ambulatory sectors of the health care system and continuity of care across networks of service providers.

Dr. Vissers described the hierarchical levels of decision foci in his book as follows: (a) strategic level decisions such as centralized versus decentralized operations, and contracted patient volume, (b) amount of resources available at an annual level, (c) time-phased allocation of shared resources, (d) urgency and service requirements, and (e) scheduling of individual patients.

Dr. Vissers is using OR models imbedded in several case studies he is developing for his book. For example, one case study concerns admission planning and case-mix decisions. The question here is to determine the ideal mix of patients that should be admitted each day of the week to even out use of specialized resources as well as achieve the minimum threshold of patients in each category that need to be admitted each day to maintain good quality of service to all patient populations. This study utilizes a mixed integer programming formulation of the problem, which is the basis of a decision-support system. In another case study, he develops a duty roster (rotation schedule) for specialists using multiple criteria. The model uses a simulated annealing approach, which is imbedded in a decision-support system. The aim is to improve an existing schedule, rather than to find the optimal schedule. Yet another case study develops business planning for surgical specialties by balancing wait lists and output. Wait lists exist for both inpatient and outpatient categories. In addition, certain amount of capacity is consumed by emergency arrivals. The key question is how many patients in each category should be served? Typically, a common wait list exists for each specialty unless there are some highly specialized service providers whose services are not duplicated by others.

Although there is considerable interest in carrying out studies of patient flow, this is currently limited by the absence of a link between inpatient and outpatient data. Therefore, longitudinal studies of patient data use data mining techniques. In addition, in some cases, manual data collection has been done. For example, a web-based system was developed to track patient flows for cardiac care. In this system, each unit in the chain of care reported the patient arrival, procedure and departure time information via the Internet. This information was entered manually. The data is being used to study how the chain should be reorganized.

### **United Kingdom**

The United Kingdom appears to have the greatest amount of research activity in capacity planning. These projects are being carried out at the Clinical Operational Research Unit (CORU) of the University College, London, at the two OR groups of the Department of Health, and at Universities like Warwick, Southampton and Lancaster. In some instances, the projects have an OR component, but involve an interdisciplinary approach. This section contains a description of some of the projects about which we learnt first hand during a meeting with several researchers at CORU.

Professor Steve Gullivan, director of CORU, is looking at queue lengths and change management issues associated with DTCs. This study of queue lengths will include optimization models to select the

appropriate case-mix and the impact on waiting times of the reduction in LOS variability. Work on this project has only recently begun.

In another project led by Professor Gullivan, he is interested in the efficacy of screening for cervical cancer. Specifically, in one of his investigations, he is developing models necessary to answer questions about timing of screening when capacity/resource constraints limit the frequency of screening to say, two or three, in a patient's lifetime. Such models are useful for developing a recommended testing protocol for patients in poorer nations. Similar timing issues arise in Professor Gullivan's work on asymmetric left ventricular failure, which can be detected by a blood test. If the blood test is positive, it is usually followed by a cardiogram. Professor Gullivan is developing models to identify the right age for screening, while accounting for different types of co-morbidities, with the goal of improving cost-effectiveness. He is also interested in the impact of such medical decisions on capacity requirements. In a number of these models, Professor Gullivan uses discrete-event simulation and semi-Markov processes methodology with input data coming from randomized control trials and epidemiological studies.

Dr. Paul Harper from Southampton has several projects that deal with capacity planning and patient flow issues. His work uses discrete-event simulation and systems dynamics models. Broad areas of his research interests include capacity planning models, models for deciding where to locate cardiac service centers, and case-mix/LOS prediction models. He has also been active in hospital planning; specifically, the impact of private funding, and outpatient scheduling, and how scheduling systems can help meet the patient charter, a set of patient expectations produced in 1991 that the British health care delivery system is expected to meet to provide greater accountability. One aspect of this charter is the edict that no patient should have to wait for more than 18 months for an inpatient hospital procedure, with the preferred waiting time of under 12 months.

A current area of interest for Dr. Harper is workforce planning at the regional level. He is attempting to determine the staffing requirements, by grades of expertise, for hospitals, Trusts, and regions to meet demand for the next 10 years. At present, only crude ratios, e.g., the proportion of occupied beds, are used for this purpose. Dr. Harper is developing more sophisticated methods that include different levels of dependency of patients and the fact that the dependency levels change over time. He hopes that a key output of such planning exercises will be the identification of workforce training needs – i.e., how many doctors, nurses and allied health professionals should be trained. At present, there is a shortage of doctors and nurses, particularly intensive care and operating room nurses.

Dr. Harper notes that the Department of Health does have a systems dynamics model to perform workforce planning. He is also interested in doing Intensive Care Unit (ICU) workforce planning on a regional level. He thinks that models can help understand the impact of sharing/pooling of capacity for intensive care in a region.

Although Professor Sally Brailsford's primary research area is modeling disease transmission and technology assessment, she has also used systems dynamics models to investigate the flow of patients in the emergency department of a Nottingham hospital. The model was used to test the impact of different unit configurations on patient service, including the effectiveness and efficiency of walk-in centers.

Dr. Dave Worthington of Lancaster University has an ongoing interest in wait list management issues and appointment scheduling systems. He sees the former as capacity planning and the latter as patient flow management problems. In the past several years, Dr. Worthington has had a great deal of interaction with the NHS Modernization Agency, mostly in the area of wait-list management. For example, he describes efforts by the NHS Wait List Initiative as being focused on encouraging group practices for consultants in hospitals (i.e. forming a single wait list for services). The initiative is based on the well-established OR principal of efficiencies related to pooling of queues. Dr. Worthington listed another example, a scheme called Clinical Prioritization. This is an effort to get clinicians to set priorities for their patients and then to treat patients in the priority order to achieve clinical goals.

Dr. Worthington is also working to improve operations at various hospitals through MS student projects. In the previous year, he has been involved with two projects. One project is a "top-down" model, in which the student team developed a set of tools in Access and Excel to analyze nationally available data to identify Trusts with good (or bad) wait lists. The second project was a "bottom-up" approach to develop Improvement Leaders' Guides – documents that outline solutions to common operational issues. Dr. Worthington believes that in many clinical environments, decision makers are simply too busy to take on

the additional burden of operational improvement projects. This initiative gets around some of the initial learning curve in process improvement by inserting analysts to initiate a project. They involve hospital decision makers and do some education and training in OM techniques such as process mapping, quality control, and Business Process Reengineering. The team builds up expertise at the local hospital and guides them through the improvement process. Using success stories, the team develops guidelines for decision makers in other institutions who may be facing similar issues. The analysts disseminate the findings and act as a resource for individuals in other Trusts.

Overall, the British researchers feel that systems level OR models should be used to evaluate the impact of policy change at the strategic level. At present, health care policies tend to be highly political. They are not subject to much analysis. This leaves a large and significant area of decision making which is currently not served by the OR community.

### **SUMMARY OF FINDINGS AND CONCLUDING REMARKS**

It is apparent from our meetings with European researchers that capacity planning methodology is not under scrutiny in countries where capacity/resources are seen to be ample. In contrast, in countries where capacity shortages have resulted in increasing wait times, capacity planning methods are taken seriously and OR methodology is making an impact on the decision-making processes. However, most of this effort is directed at the unit level and utilizes relatively simple tools. Capacity planning at the level of a chain or network is still not happening, although the single dominant payer system makes it possible to perform such analyses at regional and national levels. [Lack of political will and relevant data are often cited as reasons.]

Another emerging trend is the effort to organize specialized high-volume treatment centers that take care of more routine procedures (with less variability). These clinics are expected to lower costs and reduce congestion at general hospitals that take care of patients with much greater variability in their diagnoses. Such treatment centers are a new concept and whether or not they will help reduce cost and improve access is not yet clear. However, their emergence does provide new opportunities for OR researchers to develop both descriptive models of their impact on service networks and optimization models for setting their operational parameters (e.g., case-mix and staffing needs).

System-level mismatch between capacity and demand is not addressed by current capacity planning efforts, with the result that odd results can occur when more capacity is made available in one part of the network. Part of the difficulty here is the problem of estimating true demand, which requires carefully constructed disease propagation models and a well-defined benefits catalogue. Many researchers we interacted with have built discrete-event simulation-based disease propagation models, but their use is currently restricted to testing various screening and treatment protocols (or health technology assessment). These models are not tied to capacity requirements planning. Thus, an important theme that emerges from our study is that capacity planning and the assessment of screening and treatment protocols for various diagnoses ought to be closely intertwined. This calls for a greater integration of health technology assessment studies and OR methodologies for capacity planning and cost-benefit analysis.

It also became apparent from our meetings that researchers in many countries advocate the use of OR methodology in evaluating strategic decision choices (i.e., in setting national and international level health policy). These decisions often define the parameters under which regional capacity planning takes place. Designing a health care delivery system to meet system-level performance metrics (e.g., the patient charter in the U.K.) remains a difficult task. Moreover, OR has yet to make a mark on the process by which performance standards and expectations are set, and corresponding capacity requirements are assessed, at the national level.

Modeling patient flows and comparing patient populations served by different networks of providers is of interest to many of the researchers we interacted with. However, this is limited by the absence of a link between data systems of various health care sectors; mostly notably the ambulatory and the non-ambulatory sectors. As a result, a system-level model of health care resources and patient flows is feasible and needed, but lacking.

## CHAPTER 4

# HEALTH TECHNOLOGY ASSESSMENT AND PUBLIC HEALTH

François Sainfort

### INTRODUCTION

Today, because of scarce resources for health care, the explosion of new health and medical technology, and the cost of new health and medical technologies, the need to ensure cost-effective use of health technologies has become a critical public issue in all health care systems around the world. As a result, Health Technology Assessment (HTA) is, or is becoming, a critical function in any health care system. The main approach used across most health care systems consists of conducting cost-effectiveness analysis, a standard tool used in health economics, whereby the costs and benefits of one health intervention are compared with costs and benefits of another by calculating the incremental cost-effectiveness ratio, which expresses the cost per additional unit of health benefit conferred for one intervention compared to another [Gold et al. 1996]. The field of HTA lends itself to a number of opportunities for the field of operations research and systems sciences, both in terms of applications and research, and hence is one focus of this report.

This chapter examines HTA work conducted in the public health arena in five countries, with a focus on Operations Research (OR) used in the context of health technology assessments. Applications of HTA, active research areas in the field of HTA as well as state-of-the-art OR work being done in related aspects of public health are described. The five countries are:

- United Kingdom
- Germany
- Austria
- The Netherlands
- France

### UNITED KINGDOM

Significant funding is available in the United Kingdom for research studies related to HTA.\* Most funding is being directed toward randomized clinical (or control) trials (RCTs), which generate data that is useful for subsequent HTA studies. Therefore, it is not surprising that there are many researchers there who are interested in applying their models and techniques within that field.

Several government health agencies are involved in HTA-type research. For example, HTA represents the largest single research area for the Department of Health (DH), which is responsible for developing health and social care policy and guidance in the U.K. The National Institute for Clinical Excellence (NICE), part of the National Health Service (NHS), provides national guidance related to treatments and care for NHS patients in England and Wales. It was organized specifically to evaluate new treatments and drugs and to conduct HTA. Furthermore, one of the three primary research streams at NHS specifically focuses on HTA. Finally, the

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\* For more information on funding and sources in the U.K., see Chapter 2, "Trends in Information Technology and Chronic Disease Management," by John Blake.

Medical Research Council—similar to the National Institutes of Health (NIH) in the United States—also funds clinical trials and HTA.

Current projects in the U.K. include research into the cost-effectiveness of screening programs, such as those for Down Syndrome and cervical cancers, as well as those in the developing world where funding is limited. Other current HTA projects include end-stage renal disease, diabetes, coronary heart disease, and HIV/AIDS.

Studies are being planned that will look at ways to develop new OR methods to address a wide range of issues in the U.K. For example, researchers are very interested in developing new health impact assessment methods in conjunction with environmental impact assessments and in developing new methods for risk assessments in order to improve HTA studies. Future research within the OR field will be directed towards designing new evaluation methods and techniques in the absence of RCT data, in part to reduce costs because RCTs are typically very expensive. Another future project will be screening for asymptomatic left ventricular failure. From a more methodological standpoint, researchers will look at how co-morbidities can be accounted for and how they can influence the effectiveness of different screening programs.

Another group plans to develop methods for identifying where a given diagnostic test needs to be placed on the Receiver Operating Characteristic (ROC) curve for that test to be cost-effective. The ROC curve is a way to represent the diagnostic accuracy of a diagnostic test. In the U.S. this approach is often referred to as “the challenge region.”

## GERMANY

The focus on explicit control and regulation of health technologies was not a major issue in the past. While regulations for licensing pharmaceutical and medical devices was important, other types of technologies did not receive much attention. As noted by the International Society of Technology Assessment in Health Care (ISTAHC, 2002, p.9), “keys to the rapid change of that situation were both the stimulating efforts of networking on a European and an international level as well as an increasing reliance on HTA in regard to the support of decision making on different levels of health care.” The German Scientific Working Group Technology Assessment for Health Care was established in 1997, as a direct result of the German HTA project, funded by the Federal Ministry of Health starting in 1995.

As in the U.K., significant funding is available in Germany to support HTA. The most significant funding source by far is the German Ministry for Health and Social Affairs. Other potential sources of project funding include three Directorates-General within the European Commission (Research, Health & Consumer Protection, and Employment & Social Affairs), the German Research Council, and several philanthropic foundations.

A number of HTA activities exist and include several institutions, including the Office of Technology Assessment at the German Parliament. The major activity can be observed in the use of HTA results by the Federal Standing Committee of Physicians and Sickness Funds for the purpose of decision making on the coverage of technologies in the benefits catalogue (ISTAHC 2002). Current HTA projects in Germany include cystic fibrosis, drug therapy in terminal illness, and coronary heart disease. Furthermore, German researchers have expressed great interest in conducting comparative studies among EU countries.

While a more systematic approach to HTA and its use has started, there are still considerable inconsistencies in the different health care sectors (especially between ambulatory and in-patient settings) with regard to coverage decisions and the management of diffusion and usage of health technologies (Ibid). The Reform Act of Statutory Health Insurance 2000 was implemented with the aim of improving this situation and strengthening the use of HTA in the system. Interestingly, in the future, information technology hardware and software will be evaluated to determine whether and where investments are justified, just as, in the past, health and medical technologies were similarly evaluated. An Institute for Quality and Efficiency in Health Care is currently being formed; hopefully its HTA studies will provide some opportunities for operations researchers to test, develop, and implement new techniques. A joint committee between the sickness funds and health care providers in Germany is being formed to make decisions about benefit catalogs. This work will require HTA studies to define those benefits that should be placed in the catalogues.

Longitudinal studies of disease, utilization, and evaluation of health technologies are currently being pursued in Germany with the goals of creating guidelines and establishing contracts. A brand new program in Berlin with

an educational perspective is being implemented whereby comprehensive evaluations of health technologies will be conducted from their inception through to their implementation and utilization within the health care system.

## **AUSTRIA**

Only recently, strategies for steering the cost-effective use of health technologies have become an important public health issue. Although not yet institutionalized as an instrument to support and/or control the dissemination and use of health technologies, a substantial amount of HTA is now being performed in Austria. One academic institution in particular has been performing HTA over the last decade: the Institute of Technology Assessment at the Austrian Academy of Sciences (Ibid).

The research funding sources are very similar to those available in Germany. Funding is available from the European Union as well as two funds—the Healthy Austria Fund and the Austrian Research Fund—several Austrian government ministries, and the Austrian National Bank. All of these organizations currently fund HTA research in Austria and have expressed interest in continuing to do so in the future.

Operations researchers in Austria are involved in a number of projects, including the evaluation of government policies related to vaccination and AIDS/HIV. Other topics of research include HIV and hepatitis C transmission and prevention, coronary heart disease, drug use and prevention strategies, and diabetes. The research in Austria has raised a number of research questions; for example, in diabetes research the goal is to develop good models of how the disease evolves over time and how different treatment strategies will slow down the progression of the disease and prevent complications.

## **THE NETHERLANDS**

Like many small European countries, the Netherlands has a long history of interest in HTA and medical technology assessment. For example, transplant programs are evaluated before any treatment decisions or screening programs. It appears that this trend is due to the fact that health research in Europe, especially in those countries without a domestic pharmaceutical industry, is performed with an emphasis on cost containment, thus supporting HTA-type research that can be used to justify the costs of drugs within the health care system.

The Netherlands has a very active HTA program today. The Institute for Health Technology Assessment, in Rotterdam, is the largest of its kind in Europe. It employs about 35 high-level researchers, a mix of operations researchers, public health people, and economists. More than 60 percent of the funding for the institute comes from the pharmaceutical industry, and the rest comes from the government and other sources. Cost-effectiveness analysis (CEA) has been part of medical studies for quite a while in the Netherlands, which also has a large and talented group developing improved utility- and question-based methods for health-related quality-of-life assessments. Current HTA projects in the Netherlands include:

- Alzheimer's
- Hypopituitarism
- Erectile dysfunction
- Fecal incontinence
- Leukemia
- Migraines
- Spinal cord injuries

There is a strong interest in forming a national institute modeled after NICE in the U.K., and this will most likely happen. HTA will soon be introduced as a requirement for any drug before it can be sold and for medical technology producers before they can distribute medical technology in the Netherlands. Furthermore, extensive research is being conducted into new methods for quality-adjusted life years (QALY) assessments and for determining how to use the information obtained from these assessments in the context of HTA and cost-effectiveness models. Such research is described further in a subsequent section.

## FRANCE

Interest in HTA in France does not appear to run as deeply as in the Netherlands and other European countries. This is due, in large part, to a limited number of funding sources. Funding is available from the EU, the French government, and the private sector. In addition, French researchers have been able to obtain some funding directly from Federal agencies in the United States such as NIH, the Centers for Disease Control and Prevention (CDC), and the Environmental Protection Agency (EPA) to conduct operations research in related public health fields.

Much of the HTA work being done in France is performed directly by government agencies, in particular INSERM, the National Institute for Health and Medical Research, and ANAES, the National Agency for Accreditation and Evaluation of Health and Health Care. Unlike health research organizations in many other countries, INSERM conducts OR that is directly applicable to epidemiology and public health. Areas of research interest include AIDS vaccine trials and methadone programs.

Current HTA projects at ANAES include research in age-related macular degeneration, hip replacement, cardiovascular disease, the use of robotics for surgery, and the evaluation of imaging studies and technologies. ANAES has a small extramural research program that permits a limited number of outside researchers to participate.

An estimated 45 to 65 percent of medical technologies that are now being used have no research-based evidence of effectiveness. To address this problem, future HTA research should, for example, focus on better identification and resolution of issues related to health technology deployment and implementation.

Under the leadership of Professor Chick at INSEAD, a strong OR group is pursuing state-of-the-art research in public health by developing sophisticated stochastic infection models for AIDS and other STDs; modeling infection/transmission rates in novel and powerful ways, and developing new associated risk assessment methods. In the future, the objective is to eventually consolidate the various techniques and models into tools that will assist decision-making processes in various fields, such as secondary transmission risks and water treatment decisions (the latter in cooperation with the U.S. EPA). Chick and his colleagues are leading modern risk assessment research along a hierarchy of modeling techniques involving increasing levels of complexity: from systems dynamics models, to stochastic models, to microsimulation models, and finally to dynamic social network models (e.g., Riolo, Koopman and Chick 2001). These techniques, and especially their integration into usable decision support tools, hold great promise for the analysis, control and surveillance of infectious diseases as well as in the analysis of the effectiveness of health interventions and technologies.

## RESEARCH ISSUES

Research issues in the field of HTA (addressed primarily in the Netherlands) include the development and implementation of appropriate methods for measuring and estimating costs as well as measuring and estimating effectiveness; the development and implementation of a variety of mathematical and statistical models to examine, represent, and analyze the impact of diseases and conditions on individuals and populations over time; and the development and implementation of economic models to predict and analyze the costs related to health technologies at individual and population levels over time.

As noted by Kongnakorn and Sainfort (2004), the measurement of health outcomes is a critical matter in medical decision making and health technology assessment. Clearly, when clinicians and patients make clinical decisions such as choosing among alternative medical treatments, they base at least part of their judgment on their perceptions of expected relative gains or losses in future health. The existence of a good metric for measuring future health resulting from alternative treatments would greatly facilitate the process of making such decisions. Indeed, the ultimate goal of medical treatment, and of health technologies, is not to improve a particular clinical parameter or eliminate particular symptoms, but to improve the health of patients. There is little dispute that improving health in medicine involves two main components: increasing life expectancy or "length of life" and increasing "quality of life" of patients [Fryback 1998]. Clinical outcomes defined in terms of mortality or physiological measures such as blood pressure or intermediary diagnostic test results, are often necessary, but insufficient, for making a final treatment decision. Patients' preferences for health outcomes need to be captured and explicitly included when contrasting and evaluating alternative treatments for making medical decisions. Thus, any health outcome measure would need to account, in some way, for both length and quality of life.

Similarly, at the population level, capturing and aggregating individual preferences is also often deemed necessary for evaluating new treatments, health services or health technologies. Failure to include such information may result in suboptimal decisions that do not conform to individual or societal preferences. In HTA, an important goal is to permit comparisons across diseases or conditions. Therefore, health benefits need to be expressed in generic terms such as “health-adjusted life years” (HALYs), as opposed to disease- or condition- specific terms (such as number of disease-specific cases averted).

HALYs are viewed as a large field of research encompassing a number of measurement systems, which differ in at least three overall dimensions: (a) disease-specific versus generic measures; (b) non-preference versus preference-based measures; and (c) use for individual versus societal decision making. A generic measure permits comparisons of health benefits across diseases or conditions and is not naturally tied to a certain disease or condition (as would be the case with physical measures such as blood pressure or total cholesterol level or a condition-specific rating scale such as a scale measuring back pain). As noted by Fryback [Ibid], another fundamental difference between measurement systems is whether the numbers generated reflect individual preferences for different health states—and thus are derived from human judgment about the relative desirability of being in one health state versus another—or are derived in a manner not directly related to preferences. For example, the eight scales of the short-form health survey SF-36™ [Ware and Sherbourne 1992] produce numbers that do not reflect individual preferences. Utility-based models such as the Health Utility Index [Torrance et al. 1982], on the other hand, are specifically designed to reflect preferences.

Finally, it is important to note that measures designed to support individual decision making may or may not lend themselves to aggregation across individuals in a population to assist in societal decisions. Thus, in terms of the applicability and validity of measurement systems, it is important to consider the viewpoint being adopted. In the U.K., Nord et al. [Nord et al., 1999], for example, have identified a number of limitations in aggregating individual measurements of health-related quality of life for assessing the societal value of health care investments and have proposed adjustments for dealing with such problems.

A number of measurement systems have been developed by researchers from many different disciplines. The most widely used model, developed with contributions from operations researchers, economists and psychologists, consists of the QALYs model, a generic, preference-based measurement system designed to assist in individual decision making. It is widely used for societal decision making and health technology assessment, provided that its limitations are properly dealt with [Nord 1999]. In Europe, health is described in the EQ-5D system, a system developed by the EuroQol Group (1990), an international research network established in 1987 for self-health assessment by researchers from Finland, the Netherlands, Sweden, and the United Kingdom. The EQ-5D presents health in terms of five dimensions: mobility, self-care, usual activities (work, study, housework, family, or leisure), pain or discomfort, and anxiety or depression. The model is a generic measurement system designed primarily for studying population health and performing cost-effectiveness analyses. Research continues to be extremely active in this area throughout the world but especially in Europe and in the United States.

## SUMMARY

In terms of research funding, HTA predominates in European countries. As a result, more OR people are involved in HTA than in other research areas covered in this report. Much of the work is being done by government agencies, which provides opportunities for OR groups to participate, thereby testing new methods and contributing to the field.

Very few government health care agencies, with the exception of NHS in the U.K., actually have an OR group working with them. Agencies in France, for example, are dominated primarily by clinicians, public health professionals, and economists. The focus areas of HTA studies vary from country to country depending on their perceived needs and available resources, though several comparative studies are currently being performed among EU countries.

From the standpoint of OR, most of the HTA work being performed in the countries discussed here is of an applied nature. That is to say, most studies use existing tools and focus on a single medical technology or disease of interest. Much less research is being done on the methodology behind the conduct of HTA studies themselves. Two notable exceptions are the Netherlands and France. Research in the Netherlands has a heavy

methodological research focus on outcome measurements and health-related quality of life assessments. Research in France has a heavy methodological focus on research into epidemiologic and public health issues.

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## **APPENDIX A: PANEL BIOGRAPHIES**

### **FRANÇOIS SAINFORT, PHD**

François Sainfort is the Associate Dean for Interdisciplinary Programs at the College of Engineering and the William W. George Professor of Health Systems in the School of Industrial and Systems Engineering at Georgia Tech. Dr. Sainfort's research and expertise focus on the development of mathematical modeling techniques for medical decision making, health outcomes measurement, health status assessment and monitoring, and health-related performance analysis. Dr. Sainfort has received research funding from the U.S. federal government – the Agency for Healthcare Research and Quality, the Health Care Financing Administration, the National Institute of Aging, the National Library of Medicine, the Centers for Disease Control, the National Science Foundation, and the Department of Defense – as well as funding from industry. Dr. Sainfort has published over 100 refereed publications that have appeared in health care journals such as Health Services Research, Medical Care, Medical Decision Making, Medical Care Research and Review, Health Care Financing Review, American Journal of Psychiatry, The Gerontologist, Diabetes Care, and Quality of Life Research. His research has also appeared in operations research journals such as Operations Research, Journal of Multi-Criteria Decision Analysis, Organizational Behavior and Human Decision Processes, International Journal of Human-Computer Interaction, Journal of Society for Health Systems, and Industrial Engineering Research.

### **JOHN THOMAS BLAKE**

John Thomas Blake is an Associate Professor in the Department of Industrial Engineering at Dalhousie University in Halifax, Nova Scotia. Previously he served as Adjunct Scientist for Canadian Blood Services. He also spent time as Assistant Professor in both the Faculty of Medicine and Engineering since 1997 at Dalhousie. His articles have been published in many refereed journals and books, including Socio-Economic Planning Science, Interfaces, European Journal of Operational Research, Anesthesia & Analgesia, Anesthesiology, Surgical Services Management, and the Journal of the Society for Health Systems. His research has been funded by grants from the Nova Scotia Health Research Foundation, the Children's Hospital of Eastern Ontario, Mount Sinai Hospital, Ontario Ministry of Health and NSREC. He is a member of the Association of Professional Engineers of Nova Scotia (APENS), The Institute for Operations Research and Management Sciences (INFORMS), and The Canadian Operational Research Society (CORS). Last year he became President of the Health Applications Section at the Institute for Operations Research and the Management Sciences (INFORMS), after first gaining title as Treasurer in 1999. He graduated with a BA of Science in Industrial Engineering from the University of Toronto, where he also obtained a PhD in the same field in 1997.

### **DIWAKAR GUPTA**

Diwakar Gupta teaches in the Graduate Program in Industrial Engineering at the University of Minnesota. This program resides in the Mechanical Engineering Department where Diwakar holds the rank of Professor. Diwakar got his PhD in Management Sciences from the University of Waterloo (Canada). Before joining the University of Minnesota, he has taught at the Technical University of Nova Scotia (now part of Dalhousie University) and at McMaster University (both in Canada). His primary research interest lies in the area of Stochastic Modeling with applications to manufacturing systems, inventory management and health care delivery systems. His research papers have appeared in such journals as Operations Research, Management Science, IIE Transactions, and EJOR. In the health care field, his articles have been concerned with capacity reservation for elective surgeries, pooling of blood samples to reduce the cost of testing for HIV antibodies, and appointments scheduling. Diwakar Gupta is the principal investigator on several sponsored research projects and the director of the Supply Chain and Operations Research Laboratory ([www.me.umn.edu/divisions/ie/scorlab](http://www.me.umn.edu/divisions/ie/scorlab)). One of these projects seeks to understand the success factors of same-day appointments systems and to develop models for improving dynamic assignment of appointment slots to patients. Diwakar Gupta is an Editorial Board Member of IIE Transactions -- Scheduling and Logistics, and the M&SOM Journal. In addition, he is an Associate Editor with the journal IJFMS.

**RON RARDIN**

Ronald L. (Ron) Rardin is Professor of Industrial Engineering at Purdue University and Director of the Purdue Energy Modeling Research Groups. He recently returned from a three-year rotation as Program Director for Operations Research and Service Enterprise Engineering with the National Science Foundation. Dr. Rardin obtained his BA and M.P.A. degrees from the University of Kansas, and after working in city government, consulting and distribution for five years, earned a PhD at Georgia Institute of Technology. His current teaching and research interests center on large-scale optimization modeling and algorithms, including their application in health care delivery, transportation and logistics, and energy planning. He is an award-winning teacher of these topics, and co-author of numerous research papers and two comprehensive textbooks.

## APPENDIX B. SITE REPORTS

- Site:** Department of Health Care Management  
 Technical University Berlin  
 Straße des 17. Juni 145 (5. OG)  
 D-10623 Berlin, Germany  
<http://www.wm.tu-berlin.de/fachgebiet/mig/index2-x.htm>
- Date Visited:** November 4, 2003
- WTEC Attendees:** R. Rardin (Report author), D. Gupta, T. Bartolucci, F. Sainfort, J. Blake, J. Twomey
- Hosts:** Dr. Reinhard Busse, MPH, Professor, Department of Health Care Management,  
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### OVERVIEW

Professor Busse began the meeting with a brief overview of the history of Operations Research (OR) in health care in Germany. Although Germany pioneered public health a century or more ago, he indicated that most activity stopped during the Nazi and postwar period of German partition. Beginning in the late 1980s there was an effort at the Federal level to provide targeted funds to establish a series of centers based on the Johns Hopkins model of schools of public health. Three centers were established at Bielefeld, Hanover and Berlin, joined later by Düsseldorf, Munich and Dresden. The total level of funding was in the range of €50 million over 10 years. Each center developed its own research focus, but health service research did not emerge as an emphasis at any of them until the second round of funding in the 1990s.

Unfortunately, funding for these federal centers mostly ended around 2002. At the same time, however, other parts of academia began to take an interest in health care delivery, especially in the management community at Cologne. New degree programs have also begun to be created at the universities of applied science as a result of the European Union Bologna plan to reformat higher education on a BS, MS, PhD model similar to the United States. Prior to that time, master's programs were quite rare in continental Europe.

Professor Busse continued by describing current funding opportunities in Germany. Funding from the European Commission is available under the 6th Framework Program (mechanism to fund and promote research) according to seven thematic priorities (e.g. genomic, IT, nano, food quality and safety, aeronautics, sustainable development, citizens and governance in knowledge-based society). Professor Busse was aware of one award related to health services on the subject of “costing of individual services across the EU; i.e. how to reimburse services across borders.”

Funding from the German Research Council (DFG) is difficult to obtain, because granting councils are discipline specific and there is a question as to which council will support health care service research. The DFG does provide funding for PhD students in the range of 10 to 20 students per year. Currently this includes one student in health care service research. In the past DFG provided funding for eight scholarships plus the cost of running the program. However, after the initial three-year review the program was stopped because the research focus was too diverse. Professor Busse stated that the DFG does not have an operations research component.

Professor Busse referred to other sources of money available to fund health service research: the sickness funds and the various ministries such as Health and Social Affairs, which funds the Health Technology Assessment Center. He went on to explain that such funds are politically and practically oriented and tend to support decision-making processes.

At this point, Professor Rauner gave an overview of the development of operations research in health care service research, and general activities and funding in health care service research in Austria. According to

Professor Rauner, the original work of health care service research came out of medical schools, where the focus was on ‘social health.’ This had some obvious connections with informatics and hence a connection to engineering schools.

Dr Rauner traced the development of Austrian research on health care logistics in the late 1970s and 1980s to the influence of German Professor Meyer at the University of Nürnberg. Meyer is now retired, but his research assistant Dr. Heidenburger has re-established the work in Vienna. Growing out of a production systems point of view, it involves simulation and optimization work on disease management. At the University of Vienna two courses are now offered: Innovative Technology Management in Healthcare and OR in Healthcare. Both courses are offered at the undergraduate level. Rauner explained that the applied science universities in Austria offer courses in operations research but do little research. Currently Professor Rauner and her colleagues specialize in simulation and optimization for disease management. At this time they have a few MS-level students and, like other European countries, are completing the move to a BS, MS, and PhD education track.

More generally, the Austrian Academy of Science is active in health technology assessment. In this area the Academy has conducted a number of seminars and has collaborated with health technology assessment groups in Europe and throughout the world. The Institute for Advanced Studies in Vienna focuses on health economics and contributes to the Organisation for Economic Co-operation and Development (OECD) reports as well as the European Observatory studies. The Austrian Federal Institute for Healthcare mainly produces qualitative studies.

Professor Rauner was then asked ‘where was research conducted?’ She responded that most researchers have come to health care from production and logistic backgrounds, and that this is done typically later in their careers. Researchers work in a variety of areas, including the application of control theory to drug usage, process management, and Data Envelope Analysis (DEA) models applications to health care funds. At the University Vienna the focus is on strategic planning and optimization, and most recently, scheduling. In the past Professor Rauner has worked with Margaret Brandeau on AIDS policy, with Sally Brailsford and Steffen Flessa on vertical transmission of disease, with Ruth Davies on coronary heart disease, with Liam O’Neill on benchmarking of general practitioners (GPs), on hepatitis-C transmission and prevention strategies, and nurse scheduling. She has also worked with Kevin Leonard to conduct studies of the health care financing system in Austria and Canada and has written on the impact of Diagnosis Related Grouping (DRG) type of reimbursement in European systems. In the future she will investigate vaccines in terms of efficacy and length of time to eradicate diseases.

Professor Rauner was then asked to comment on strategic issues for health care service research. According to Professor Rauner, Austria has nine counties, each with their own independent hospital system, their own reporting structure and sickness funds. In each county the use and form of information technology varies greatly, but at least once sickness fund has a good IT system. For this reason, researchers have limited access to data. In continuing her discussion of strategic issues she outlined a number of questions that tend to be addressed by the various Ministries:

- Which funding [insurance] system is appropriate?
- How should service components be integrated?
- What is the impact of the aging population?
- What is the appropriate size of the system?
- How can affordability be maintained?

Professor Rauner was then asked to comment on the impact of operations research models. Professor Rauner explained that there has been some success in areas, such as regional optimization models to examine such things as the opening of closing of facilities, DEA benchmarking, and disease and injury prevention. She continued by stating that, in general, the Austrian Research Funds don’t recognize operations research in health care or the economics of health care. Approximately 8% of funding is given to informatics and 8% for economics. In her opinion, operations research must carve out a niche in these granting councils. Professor Rauner stated that there were other funding opportunities available from agencies such as the Austrian National Bank for economics and from the European Union, as described by Professor Busse.

Professors Busse and Rauner were asked how patient flow affects the research agenda in their respective countries. Professor Busse responded by providing his vision for three levels of research.

The Macro level addresses integration issues across the European Union, international health care policy research, and new technology research (including IT).

The Mezzo level addresses institutional management. This can include:

- Defining outcomes and indicators. Here, special targeted data collection is required.
- A DEA evaluation of the efficacy of public versus private hospitals.

In Germany the breakdown of public versus private institutions is 50% public, 40% not-for-profit, and 10% for-profit. In addressing this issue, data availability is a problem. Professor Busse went on to explain that data sets are so sparse that it is impossible to determine the ownership status of an institution from a central list.

The third level is Disease Management programs from the health system's point of view. This will enable better targeted compensation, and targeted sickness funds. Professor Busse believes that this is a growing area particularly in the realm of outcomes and costs. Currently, research in this area is limited by the quality and quantity of data available, especially when it comes to longitudinal data. According to Professor Busse, the focus on disease management may provide new opportunities for new data management collection systems. He went on to say that inpatient data is getting better because of the introduction of DRGs, but ambulatory data is collected for administrative purposes only. Germany does not have a centralized data set. However Austria does, in part because there are fewer counties and sickness funds.

Professors Busse and Rauner were then asked for examples where model-based decision making has been applied. Professor Rauner responded by describing how DEA models are used to find inefficiencies and to evaluate the impact of the process on efficiency. She then went on to explain that wait lists are less of an issue in Austria than in other European countries. She believes that this is due to a number of factors, including a surplus capacity, a better capability of matching supply to demand, the change in financial structure from per diem to DRG, and the regulation on planning new facilities. Professor Rauner continued by discussing the need for model-based decision making for issues related to the organization of care for the elderly.

In Professor Busse's response to the use of model-based decision making, he returned to the importance and need for longitudinal outcome-oriented data, especially for treatment and management of chronic diseases such as diabetes and breast cancer. Longitudinal data would allow researchers to assess the effects of policy and process change on outcomes.

Professor Busse continued by stating the need for research in the area of provider quality and technology assessment; e.g. the effective application of MRI. The ultimate goal may be service catalogs which set standards for sickness funds. Germany is currently developing a joint committee to bring together sickness funds and providers. This committee will have a sub-group to evaluate technology and to spin research projects out to university-based research groups.

Professor Busse was then asked if he had any work that focused on the effectiveness of information technology. He responded that he did not, but that sickness funds and providers were interested in this area.

Professor Busse was then asked how information technology was set up in Germany. He responded that most GPs have personal computers. He went on to say that most PCs are used for billing, to access guidelines, and in very few cases, to automatically generate prescriptions. Professor Busse points out that the obvious next step would be to introduce an electronic patient record, perhaps through the introduction of a smartcard. Health technology assessment will be needed to evaluate hardware and software. Currently each sickness fund issues its own card.

In response to a question concerning demand and capacity planning, Professor Busse replied that this was not much of a research topic. He continued by stating that methods for calculating capacity are crude and based on regional averages from the 1990s. Hospital mix is also determined from data from the 1990s. He went on to say that capacity might become a research issue with the move toward an integrated network of services.

In response to a question regarding interests and efforts to collaborate with departments of engineering, Professor Busse responded that the Technical University of Berlin's Medical Technology Institute and Institute for Transport and Logistics are planning to develop an undergraduate program in health care.

**Site:** **INSEAD**  
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**77305 Fontainebleau, France**  
**<http://www.insead.edu/>**

**Date Visited:** November 6, 2003

**WTEC Attendees:** F. Sainfort (Report author), R. Rardin, D. Gupta, T. Bartolucci, J. Twomey, J. Blake

**Hosts:** Stephen Chick, Associate Professor of Technology and Operations Management,  
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## BACKGROUND

Chick welcomed all participants. Introductions took place. The National Science Foundation (NSF) team briefly introduced themselves. Stephen Chick then presented a quick overview of INSEAD.

According to 2003-2004 data, INSEAD is one of the world's largest graduate business schools, with significant campuses in Asia (Singapore) and Europe (France). It has approximately 120 faculty in Fontainebleau and 25 faculty in Singapore. INSEAD teaches more than 840 MBA participants, 66 PhD students, and trains approximately 6,500 executives per year.

INSEAD has played a major role in education and research related to health care management for quite a while. In particular, INSEAD has a very successful Healthcare Management Initiative (HMI, see <http://www.insead.edu/HMI>), inaugurated in 1996 by John Kimberly. HMI aims to encourage and support innovative and rigorous management research on challenges facing the health care sector and to diffuse new knowledge through publication, MBA teaching, Executive Education, and stakeholder consultation. With this initiative, INSEAD is an international point of reference in health care management.

In 2002-2003, for example, INSEAD's HMI reported the following new education projects:

- A new Executive Education program for clinician-managers in the British National Health Service (NHS). The program focuses on developing leadership skills for the top hundred English health care managers. The education programs include, but are not limited to, leadership training, process management, and total quality management (TQM) training.
- INSEAD also created a business skills training program for health professionals in Eastern Europe, funded by the European Commission and in partnership with GE Medical Systems.
- In 2003, INSEAD also held the sixth edition the European Health Leadership Programme, designed to provide a select group of individuals with an educational experience that will equip them with concepts, tools, techniques, and strategies to play significant leadership roles in the challenging world of health care. The program was a collaborative undertaking with Johnson & Johnson and consisted of a two-week residential program on INSEAD's campus. This program has been very successful over the years and has a strong alumni network of top executives.
- As another example, in 2003 as well, INSEAD and Johnson & Johnson held a highly regarded two-day workshop on Innovation and the Future of Healthcare.
- INSEAD has developed a teaching case focusing on organizing for innovation in the medical device industry as well as a teaching case focusing on process improvement in health care.

Every summer, INSEAD holds a symposium on the future of health care. This symposium includes managers in the pharmaceutical industry, the medical devices industry, IT managers, etc. The symposiums gather close to 200 participants from all over Europe. The last symposium focused on IT and advances in information and communication technologies. INSEAD also organized a Healthcare 2020 forum.

A new program will be developed with medical device firms and with a focus on biotechnology research firms. This is in part influenced by the recent Génopole (a technology park around the field of genetics) started close by in Evry by former Prime Minister of France, Lionel Jospin.

In terms of research, INSEAD is very active in the health care management area. For example, in 2002-2003, INSEAD's Healthcare Management Initiative reported a number of noteworthy projects, listed below.

- INSEAD developed a research consortium and a proposal to study the role of information technology (IT) in health care across Europe.
- INSEAD has built a strong formal relationship with the University Hospital of Leuven, Belgium, to begin studies of leading academic health centers in Europe. One goal of this partnership is to work on cases, papers, and provide a fertile ground for joint collaborative research in health care management.
- INSEAD has also begun a study of change projects in the British National Health Service.

Regarding sources of funding to support research and education programs, INSEAD has been very successful, attracting funds from a variety of sources including, but not limited to:

- European Commission
- Healthcare Industry funding (Pharmaceuticals, medical devices, etc.)
- British NHS
- Software Industry
- U.S. Federal Agencies (NIH, EPA, CDC, etc.)

Obtaining a large amount of EU funding can be challenging as the EU tends to focus more on funding networks of excellence, which requires establishing a number of connections with different EU countries, rather than focusing on individual or small groups of investigators. In that way, funding is somewhat different from federal funding in the U.S., for example the National Science Foundation.

Prior to addressing specific issues of interest to the NSF panel, Chick remarked that since INSEAD has lots of contact with the U.K. and Benelux in addition to France, some of his comments will pertain to health systems in general rather than specifically in France.

### **CAPACITY PLANNING/PATIENT FLOW**

James Taboul, professor in technology management, has written a number of cases. For example, Ie Karolinska Hospital in Sweden went through a major change from budget-based payment to Diagnosis Related Grouping (DRG)-type funding. Switching to a DRG system caused operations to change dramatically and required a realignment of operations into patient flow lines. This case, while more of a management case than an operations research case, nevertheless illustrates the need for more research, as well as being indicative of the health care burden excess and demonstrating that DRG allows for and requires the process to change. The study of service operations is clearly an area requiring more work. There is a lack of formalized research to determine if a shift to DRG has improved quality and/or throughput. INSEAD researchers are pursuing research in this area.

The panel asked whether there are any initiatives on the part of the French government to look at capacity. For example, when a new hospital is proposed and designed, how is capacity set? Chick recognized that there is definitely a role for OR to play in capacity planning. However, little is being done in France. In terms of government research, there are two main structures in France: The Centre National de La Recherche Scientifique (CNRS, National Center for Scientific Research) and the Institut National de la Santé et de la Recherche Médicale (INSERM, National Institute for Healthcare and Medical Research). The CNRS funds primarily nuclear-related research but does fund health and medical studies as well, while INSERM is primarily focused on pharmaceutical research. As a result, resources are scarce to support operations research and operations management research in health care.

To address capacity planning issues at the national strategic and tactical levels, Chick suggested the use of dynamic systems concepts to model patient flows and incorporate models from different areas which focus one or two items into a larger dynamic model. As an example, the relationship of the quality of a mammogram screen to the volume and frequency of the screens should be explored. In terms of service system capacity, most models do not include issues related to limited capacity and queue, yet there are queuing effects associated with constrained capacity. Thus, screening standards could be established addressing such issues. Furthermore, there are very different practices for getting screens to individuals, especially if countries are compared (France, U.K., U.S.). Comparative studies would help every country,

as everyone is interested in increasing access to quality screens. However, how all the variables related to quality, volume, access, and capacity interact with each other needs to be carefully studied and incorporated into a dynamic model. Such unified models would be very powerful in informing strategic planning. Chick and his group have been working on such issues.

As another example, in collaboration with Leuwen, a business case was developed on organ transplant programs, specifically a liver transplant based on an incident in which someone came into the hospital needing a liver, there was a liver available, but nobody checked for an ICU bed. The patient recovered in OR for 12 hours. This started a snowball effect for capacity planning. As a result, scheduling software is now in place to schedule OR, ICU, RR, and ward beds. The case is very extensive and talks about how to identify and calculate bottlenecks, how to manage physicians, how to get systems thinking in place. It not only looks at the flow in one institution, but at the flow of patients within a network of possible sites. It addresses how one segment market can take care of different patient lines. Thus, there are a number of interesting areas of research and development including understanding strategy development and implementation, managing flows, and deploying systems thinking concepts. Chick also stressed that there is a need to get OR/operations management (OM) into the area of strategy.

Gilmartin emphasized that more systems thinking needs to be taught for individuals, especially clinicians, interested in health care management. It is critical to expose clinicians to sound management techniques and systems thinking. While the U.S. education system typically exposes its undergraduate students to systems, it is rarely the case in most European higher education systems. INSEAD, on the other hand, emphasizes such an approach.

The panel inquired about the issue of waiting lists in France. Chick remarked that the system in France is highly decentralized with a large freedom of general practitioner (GP) choice. There is, in fact, an overcapacity of GPs. On the other hand, there is an undercapacity of nurses, in part due to the 35-hour work week regulation in France. In turn, the physicians are feeling overworked. The shortage of nurses is estimated to be anywhere between 40,000 to 80,000 nurses. Operationally, the physicians maintain their own records. While many physicians type in all medical history into their own computers, the records are not linked. The level of care is generally quite high and the overall system is fairly inexpensive. Most people have supplemental insurance (Mutuelles d'assurance). Health care expenditures represent about 9-10% of the GDP. In terms of inpatient capacity, there seems to be an overcapacity of hospital beds. For example, maternal wards have an overcapacity of beds and a normal birth has a length of stay (LOS) of eight days. Emergency room capacity seems to be about right. In terms of elective surgery, capacity appropriateness is not known and there does not seem to be issues with outpatient settings.

In contrast, Chick remarked that the U.K. has major waiting lists issues and mentioned that physicians in Belgium take overflow capacity from the U.K. The patients are transported to Belgium and stay in four-star hotels for fast recovery. This is done fairly quickly and cheaply. Such practices raise issues of transnational patient flows. There is a need to use operations research/operations management techniques to investigate the inter-organizational and inter-national levels.

### **INFORMATION TECHNOLOGY (IT)**

While France has "smart cards" with a computer chip (Carte Vitale), the extent and depth of IT use is relatively low. The cards have potential but currently they are primarily used for accounting information. The IT network is flexible, decentralized and available to clients, but not complete. The GPs are not linked. Hospitals have legacy systems and generally have poor information systems. For example, of about 50 hospitals in Paris, perhaps one is a model of modern information technology implementation and use. If one wanted to study patient flow in France, getting appropriate supporting data could actually be quite a challenge. The data is disjointed, there is no central data repository, there is no equivalent to a computerized maintenance management system (CMMS) (ex-HCFA) data center. In contrast, in the U.K., the physicians seem to be better connected, while hospitals are less so. A lot of data is available on the web through the NHS (e.g., for certain types of diseases, for disease management). In France, knowledge growth and data for managing the system are important issues. There is a big push for electronic patient records. Generating and implementing knowledge management tools is perceived as critical.

### **Chronic Care/Chronic Disease Management**

As an example, Gilmartin examined and studied the readiness of East Anglia with respect to meeting national standards for diabetes. She looked at how diabetic services were delivered and investigated organizational factors affecting delivery of care. A key was to tap into expertise and spread to all clinicians. She found that clinical managers did a lot of education (i.e. best practices). She and her colleagues published a paper on OM factors and how they came to a systems understanding of care. Issues were raised regarding building capacity and building appropriate IT systems. She is working on another paper on building capacity. A key question is whether to invest in IT, and if so, how much. Gilmartin would like to pursue the research and investigate national efforts to implement clinical pathways and how IT can be more efficiently used in this context. For example, the Isreali system is very well organized and integrated from an IT perspective. They have an IT system with complete electronic patient record (EPR) and health cards: Clalit. This organization is integrated, owns pharmacies, IT firms and has perhaps 60% of the Israeli market. This organization would be an excellent case study for best practices.

In the U.K., there is a nurse-lead intermediate care system in areas where there is expertise and there are capacity issues with GPs. Such intermediate care units use triage, are protocol-based (e.g., diet, education, drug regimen), and services are delivered following a group nurse practitioner-type model with some care delivered on site. The system is in addition to, or in lieu of, the GP system and provides a workable community-based model for chronic care management.

Chick also mentioned Health Hero designed in California, a simulation-based video game for children with diabetes, providing handheld calculator for determining insulin levels and enabling patient self-care. Such successful cost-effective self-care systems should be more widespread. Few cost-effectiveness/quality studies are conducted. Performance outcomes measurement is not yet part of the culture among practitioners. Practitioners understand the revenue function but not necessarily the cost function (and tracking costs is itself an additional expense).

Asked about other studies of the creative use of IT, Chick mentioned Spain, which has a fairly sophisticated disease management program relying on IT: the Diabetic Consortium in Madrid. He also remarked that most IT development occurs in the area of telemedicine. He also mentioned STAKAS, a large telemedicine project in Finland for health care delivery with a significant research component built into the project. He also observed that Wales is investing in IT as a way of caring for a relatively large rural population. For example, radiologist now read screens remotely via information technology. Also, mobile units have been designed to provide distance consults, radiology readings, as well as drug issuing. A practitioner-to-practitioner network is being implemented.

### **Epidemiology and Public Health**

Under the leadership of Professor Chick, a strong OR group is pursuing state-of-the-art research in public health by developing sophisticated stochastic infection models for AIDS and other STDs; modeling infection/transmission rates in novel and powerful ways, and developing new associated risk-assessment methods. In the future, the objective is to eventually consolidate the various techniques and models into tools that will assist decision-making processes in various fields, such as secondary transmission risks and water treatment decisions (the latter in cooperation with the U.S. EPA). Chick and his colleagues are leading modern risk assessment research along a hierarchy of modeling techniques involving increasing levels of complexity: from systems dynamics models, to stochastic models, to microsimulation models, and finally to dynamic social network models (e.g., Riolo, Koopman and Chick 2001). These techniques, and especially their integration into usable decision support tools, hold great promise for the analysis, control and surveillance of infectious diseases as well as in the analysis of the effectiveness of health interventions and technologies.

Chick also cited other researchers in Europe performing related work. These include, but are not limited to:

- Neil Ferguson in U.K. (performing work with ordinary differential equations (ODE) and stochastic models with applications for Mad Cow disease)
- Marion Rauner in Austria (performing work on infection rates)
- Ruth Davies and Sally Brailsford in the U.K. (performing work in microsimulation)

Chick also will pursue work dealing with model transition issues, i.e., how to assist the decision maker in transitions from one model level to another level. Chick is also interested in mutation and disease resistance. In particular, modeling disease changes as well as how treatment modalities respond to such changes is an area that should be investigated in more detail. In addition, the effect of different policies and intervention strategies could be incorporated in such models.

Chick also suggested research to go beyond patient flow issues and move into how operations management and operations research can and should influence policy levers to improve public health at a macro level. Support for such ideas could be funded, for example, by the Gates Foundation Global Health Grand Challenges program and tested in underdeveloped countries.

### **Health Technology Assessment**

In terms of health technology assessment, Chick and colleagues have collaborated with peers in the U.K. For example, they performed an analysis of HTA programs in the U.K. to evaluate whether such programs have an impact on policy. A disconcerting finding was that 45% of 65 medical technologies examined and used appear to have little research-based evidence to support claims of effectiveness and thus, do not have a robust enough research base to support policy. In fact, in this work, they found only two policies with sufficient statistical power. Furthermore, many practice standards appear to have been designed on studies involving less than a dozen patients. These findings suggest a need to fund groups of researchers, rather than individuals to improve performance all across the board. A different model of innovation seems to be required in the health care delivery sector.

### **Biotechnologies**

The group asked Chick whether INSEAD is involved in research involving biotechnologies. Chick observed that there is a lot of innovation in this area, especially with regard to testing (e.g., test on a chip), diagnosis, tissue analysis, and rapid analysis of etiology. While these innovations have potential to reduce patient flow waiting times (especially for conditions where diagnosis is a significant problem), they also potentially raise important technological and organizational infrastructure issues. It also leads to further disease segmentation. For example, breast cancer is no longer seen as a monolithic disease, but as a class of similar conditions. This leads to important problems of customized drug/treatment development and administration, along with patient segmentation, triage and assignment issues. It also raises further resource allocation problems with respect to, for example, research dollar allocation. These issues offer important opportunities for operations researchers.

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## MINUTES

François Sainfort inquired if there were any other people who should be present at the meeting to round out our experience with U.K. health care. The consensus amongst the group was that the following people would make good additions to our list:

- Arjan Shahani (Southampton)
- Sally McLean (Belfast)
- Jackie Riley (Strathclyde)
- David Bensley (U.K. Department of Health)
- Authors of Checklist software ([www.checklist.co.uk](http://www.checklist.co.uk))
- Allen Baker Associates (consultants)
- Alan Brennan (Sheffield)
- David Lane (London School of Economics)
- Tillal Eldabi (Brunel)
- Steve Cropper (Keele)
- Roger Beech (Keele)
- Andre Hare (U.K. Department of Health)
- Howard Marlin (U.K. Department of Health)
- Martin Pitt (Exeter)
- Brian Dangerfield (Salford)
- Rose Baker (Salford)
- Thierry Chausalet (Westminster)
- Nathan Proudlove (University of Manchester Institute of Science and Technology (UMIST) )

Introductions then took place. The National Science Foundation (NSF) team briefly introduced themselves. The U.K. group provided a brief overview of their work.

- *Steve Gallivan* (Director of the Clinical Operational Research Unit (CORU) at UCL). CORU receives funding from the Department of Health, from directed grants, and from the Medical Research Council

(MRC). CORU applies Operations Research (OR) to clinical management of patients (i.e. screening policies).

- *Paul Harper* (Southampton). Paul has broad interests in both disease modeling and service planning including bed capacity planning, workforce planning, cost-effectiveness models, and decision models (HIV, diabetes).
- *Sally Brailsford* (Southampton): Sally describes her interests as broad. These include effectiveness/efficacy of screening models (e.g. diabetes), systems level issues (e.g. access to after-hours care), and the introduction of behavior models into technology assessment.
- *Martin Utley* (CORU at UCL): Martin works mostly on analytical approaches to capacity planning (e.g. antenatal screening) and clinical-level decision making.
- *Ruth Davies* (Warwick): Ruth has recently transferred to the University of Warwick from Southampton. She has obtained funding from the Department of Health and their agents, such as Health Technology Assessment (HTA) group for disease modeling. She does patient-level simulation modeling to evaluate screening, prevention and treatment policies.

Diwakar Gupta inquired about funding. Steven Gallivan replied that CORU gets its funding from three major sources: the Department of Health, National Institute for Clinical Evaluation (NICE), and NHS in the form of Health Technology grants.

- For the Department of Health, funding originated in 1983. Funding is long-term and is reviewed every five years. CORU does do “one-off” types of projects (e.g. recent evaluation of flu vaccine) for the Department of Health. NB: The Department of Health maintains its own OR units in London and Leeds. London group focuses on “hot” policy issues. Leeds tends to focus on capacity planning-type issues.
- The National Institute for Clinical Evaluation (NICE) is mostly comprised of economists who work in a variety of areas such as such as drug evaluation using techniques like Markov chains and decision trees. The function of NICE is to evaluate new technologies (drugs, treatments, medical devices, etc.) as they come online. NICE is primarily intended as a review board to vet proposals by firms for the use of new products. Where sponsoring agencies are not readily identifiable (i.e. surgical procedures), NICE may invite DoH to conduct research through the NHS R&D program.
- NHS Health Technology Assessment (HTA) evaluates roll-out of pressing research issues. NHS also supports two other areas of research: Service Delivery and Organisation (SDO), which manages infrastructure change, and the New & Emerging Applications of Technology (NEAT), which supports IT and OR development amongst other things. All three streams commission research at universities.
- Other Sources: Paul Harper indicated that it is possible to get funding from the Engineering & Physical Science Research Council (EPSRC). The EPSRC provide grants to individual researchers and does have a health care panel. EPSRC grants to individuals are small, peer-reviewed, generally for three-year projects and are difficult to get. Dr. Harper also noted that Medical Research Council (MRC) grants are available to the U.K. group, but are largely limited to physicians and are also hard to get.

Finally, it is possible that funding could come for specific projects from the budgets of Trusts.

The group noted it is generally necessary to piggyback OR projects onto clinical grants to receive funding. Martin Utley estimated that 10-20% of all projects going to granting agencies have some OR health care component. This fraction is increasing and it is not strictly limited to health technology assessment. Accordingly, determining the overall level of support for OR is difficult because much of it is embedded in larger grants.

Jan Twomey inquired about OR training for highly qualified personnel, specifically physicians.

Sally Brailsford indicated that no formal mechanism exists for providing OR training to physicians, except via the usual academic routes. Ruth Davies and Sally Brailsford have offered a two-day course for the OR Society, aimed largely at junior people from the Department of Health.

Ruth Davies noted that it is difficult to get employers to pay MBA-type fees for OR courses and hence the penetration of OR courses into professional programs has remained low. For example, Warwick has a Masters of Public Administration, but it has low OR content.

Steven Gallivan indicated that CORU does some undergrad teaching, but these are service courses and are not health related.

Ruth Davies indicated that Southampton provides little formal OR health care training, but notes that students may work on senior year undergrad projects that have a health focus.

The group estimates that approximately 20 PhD students who are active in areas related to OR in health care graduate annually. Total enrollment is approximately 100.

The subject of current projects was then raised by John Blake. Each of the U.K. groups responded with a brief summary of their work.

### **Steve Gallivan**

Dr. Gallivan is presently working on a project to monitor clinical outcomes of surgery. His group is working with a diagnostic and treatment center (DTC) to develop methods for error detection and reduction. Using control charts and stochastic models, adjusted for case mix, Steve hopes to develop tools to detect low-performing centers. Furthermore they hope to identify safe surgical processes. For instance, Steve's group is looking at events preceding surgery and evaluating their effects on surgical errors (i.e. wrong materials, human factors failures). Interestingly, they are using video tape to collect data regarding the surgical process.

Dr. Gallivan is also working on a project to evaluate diagnostic and treatment centers. DTCs are centers focusing on simple, routine elective cases (i.e. hips, eyes) without co-morbidities. The idea is to reduce surgical backlogs by clearing out some of the simpler cases. Funding for this project is being provided by SDO (Service Delivery and Organisation) stream of the NHS R&D program. The study looks at both quantitative (queue lengths) and qualitative (change management) issues.

In response to questions about the workings of DTCs, Dr. Gallivan and Dr. Davies provided the following background description. There are (or will be) 48 DTCs in the U.K. Each is regionally based, though London may have several DTCs whose focus may be different from those in the remainder of the country. The centers are designed to operate at high volume to gain economies of scale and to reduce the variability of patient flow. In less obvious terms the DTCs are being built to fence off capacity for elective cases from variability introduced by emergency patients. This has caused some interesting workforce issues to appear (e.g. bringing in doctors from Germany to do eye surgery on weekends, since U.K. surgeons are not available). However, DTCs do present interesting potential for the application of OR models. For instance, stochastic models to investigate the impact of lengths of stay (LOS) variability/reduction are a possible area for further investigation. Additionally, optimization models might be applied to DTC case mix selection, since there will be no emergency patients. (Dr. Gallivan noted, however, that there might be problems with case mix planning if the planned volume and mix of cases fails to appear.)

Funding flows to DTCs in a variety of ways. DTCs may be part of a Trust and get funding through the Trust. They may be Trusts in their own right. The Department of Health has already announced that funds will be made available to Trusts to support capital expenditures for DTCs. Funding decisions will be made through a competitive process; Trusts applying for funding may or may not be successful, depending on the strength of their proposal.

The U.K. group indicated that there is no method for matching need to DTC capacity. Furthermore, each Trust maintains its own lists and patients may be on multiple lists waiting for a consultation.

Another project of interest for the group is the new NHS Wait List Initiative. Under this program, if patients wait more than a prescribed period of time for an elective procedure, they must be offered a chance to jump to the wait list at another region. This initiative has been put in place by the Department of Health to put pressure on providers to limit the length of wait lists. Of course, there is the perverse situation that the WLI benefits low-risk patients and may ultimately be detrimental to overall quality of care.

At present wait lists are published and Trusts can potentially lose funds if their list is too long. However in practice no penalties are imposed for long wait times. Under the wait list initiative, patients waiting more than six months for a consultation, patients must be offered another choice of provider. Patients can elect to stay in the current list, or they may elect to jump to another queue. The alternative queue may be maintained by another NHS Trust, by a DTC, or a private clinic. In some cases, patients may be sent for

treatment to facilities outside of the U.K. through contracted arrangements between the U.K. DoH and their continental counterparts.

In pilot applications Trusts have not been penalized for shipping patients out to another wait list, but the production version may include penalties. Furthermore, at present, case management fees (i.e. the cost of running the network) have been paid for by the Department of Health; a transportation cost of about £50 per patient, on average, has been covered by the Trusts. Steve Gallivan noted that some odd situations can arise in which Trusts can act as patient donors to themselves. In London, the Wait List Initiative is called the London Patient Choice Initiative

Dr. Gallivan also described his work in disease screening, citing research such as stochastic models for antenatal screening for Down's syndrome or blood disorders. Steve is presently working on an assessment of marfan's syndrome, a congenital heart condition. Untreated, patients have a life span of about 40 years. Treatment by surgery is available, but is risky, due to lifetime requirement for anti-coagulants. Dr. Gallivan's research is designed to help patients decide when they should opt for surgery.

Dr. Gallivan also has an interest in cervical cancer efficacy. Specifically, his research is designed to answer questions such as the frequency of screening, the technology to be used, and the most effective clinical management strategy to be adopted (i.e. wait versus treatment), if anomalous cells are found. Steve is also interested in questions surrounding cervical cancer screening in the developing world. One particular question of interest is determining when screening should take place if it is impossible to screen frequently (i.e. if only two or three screens can take place over the course of a patient's lifetime.)

Dr. Gallivan also discussed his work on asymmetric left ventricular failure. This is a condition which by definition is not visible but can be detected with a blood test. Screening is being mooted as a possibility, but the cost-effectiveness of the program has yet to be determined. Dr. Gallivan is also interested in determining at what age the screen should be implemented and identifying how accurate it needs to be to achieve cost-effectiveness. In these studies, Dr. Gallivan is employing discrete event simulation using data from literature, decision trees, and semi-Markov chains. He notes that data is an issue. Since direct data is not available, he must rely on indirect sources.

This led to further discussion of data availability, particularly as it relates to chronic disease management. Because of the long time frame involved in chronic diseases and the lack of a central data record to provide longitudinal data, it is inherently difficult to judge the quality of treatment programs. For instance, cardiac surgeons employ a variety of treatment options without the ability to determine even relatively crude metrics for effectiveness, such as one- or two-year mortality. Hospital data is deemed incomplete and sometimes inaccurate for clinical management. Since hospital data is collected for reporting purposes, its value for determining clinical outcomes is limited. Moreover, since data is often presented and reported in such a way as to shed the best possible light on the reporting Trust, comparisons across Trusts are difficult.

### **Ruth Davies (Warwick)**

Dr. Davies started by describing the evolution of NHS. In the 1980s Thatcher implemented a Purchaser/Provider system to induce market mechanisms into NHS. (This model has since gone out of favor with the election of the Labour government in 1997.) Dr. Davies feels that managed competition lead to uneven access to care. (In the U.K., GPs are private practitioners, who supply services under contract to NHS. The terms of the contract are negotiated nationally between the British Medical Association and the Department of Health). GP payments are a mix of fixed allowances, capitation fees and fees for a number of specific services. Consultants (staff doctors in hospitals) are, conversely, salaried employees of NHS. Consultant salaries are fixed annually, but senior consultants do have some flexibility to provide a proportion of their services to private patients.

Because GPs' and consultants' wages were essentially fixed, contract flows between purchasers and providers were largely based on weighted volume. These arrangements lead to an imbalance in service across the country. Furthermore, any hospital actually failing due to mismanagement got bailed out, anyway. This has limited the incentive for hospitals to act in an economically prudent fashion. The purchaser and provider split largely disappeared under the Labour Government.

On the GP side, recent changes have led to an evolution from single or small practice into larger primary care networks. This has not, Ruth feels, always been beneficial for patient care. Furthermore, Trusts,

which were supposed to be a local decision-making body, often lack sufficient expertise and planning abilities.

Paul Harper agreed, and argued that there is a need to move planning tools into the hands of planners (i.e. the Checklist tool, which is useful for evaluating large-scale wait list problems). Dr. Harper argued that, at present, incredibly crude tools are used to do strategic planning and set appropriate capacity. In the realm of IT, a great deal of work remains to be done. Paul Harper noted that there is great variability in IT systems across different organizations within NHS. This leads to a situation where there is a lot of data, but little information. GP notes are less of a problem in the U.K., since paper-based notes follow patients when they move from physician to physician. (Patients are required to register with a GP when they change providers. A new GP can thus request notes from the patient's former GP). Paul noted that while GPs may have electronic record systems in their practices, the lack of compatible systems prevents transfer of electronic records. Hospital records, similarly, remain separate and disjointed from one another and from GPs.

This discussion led the NSF group to inquire about IT initiatives in general, and the electronic patient record (EPR) in specific.

The EPR is a big initiative in NHS. A system is currently under development with a release date scheduled for 2005. However, whether the system will be operational by that date is the subject of some debate. Sally Brailsford has been doing some work for the U.K. Armed Services to build an EPR. Since this system will have to interface with NHS, there is some indication it may serve as a prototype model for an EPR.

Steve Gallivan noted there has been a history of spending on IT in the U.K. without full technology assessment. Some IT projects have ultimately proven to be less effective than was otherwise hoped for. For example, a telemedicine system was installed to support women's health services in Deptford, which received no phone calls.

Ruth Davies continued her summary of her research interests. These include the assessment of chronic diseases and screening options, primarily using discrete event simulation (DES) to follow activities of patients over time (e.g. end-stage renal failure).

Ruth Davies also applies DES methodology to disease screening (e.g. diabetes, H. Pylori). She has done extensive work in coronary heart disease. In these studies Dr. Davies is looking at a variety of issues including the impact of increased revascularization and/or decreased ambulance times on patient outcomes. Funding for the coronary heart disease study comes from the Department of Health. Ruth argues that in prevention, we are treating health patients. This is something of a radical departure.

Ruth concluded with the comment that even for end-stage renal disease, for which clear definitions and treatment protocols exist, latent demand is an issue; as capacity expands so too do treatment parameters.

#### **Paul Harper (Southampton)**

Paul describes his work in health services research as varied. He works in capacity planning models, systems models, LOS/Case mix data. He has also been active in hospital planning (i.e. impact of private funding) and scheduling outpatients (i.e. what is required to meet the patient charter).

Paul is currently interested in workforce planning. He hopes to determine the staff required for hospitals, Trusts, and regions to meet demand for the next 10 years. At present, only crude ratios are used. Paul believes in developing better tools, including dependency grids that will feed data into training requirements for doctors, nurses, etc.

Dr. Harper notes that the Department of Health does have a systems dynamics model to do workforce planning. Paul is also interested in doing ICU workforce planning on a regional level.

Sally Brailsford (Southampton): Sally Brailsford describes her work as similar to Ruth Davies'. Sally builds technology assessment models that follow the individual in disease transmission, treatment, etc. (e.g. vertical transmission of HIV in sub-Saharan Africa via breast feeding).

Sally Brailsford has also used systems dynamics models to investigate the flow of patients in the emergency department of a Nottingham hospital. The model was used to test the impact of different unit configurations on patient service, including the effectiveness and efficiency of walk-in centers.

Diwakar Gupta asked Sally how demand is estimated in her models. Dr. Brailsford notes that demand estimation is a difficult task; there are some potentially serious behavioral aspects to health care demand that defy simple models. For example, cuts to the wait list for magnetic resonance imaging (MRI) tend to release latent demand. Accordingly, Sally argues for a qualitative approach during model building, combined with sensitivity analysis, post fact.

**Martin Utley (CORU at UCL)**

Martin described his primary interest as technology assessment as applied to chronic disease management. In particular, Martin is interested in answering questions related to appropriateness of care. In these studies, he has moved from strict technology assessment to expert panels, since this is a more appropriate data source. Martin has completed several exercises in the area and is looking for insight/algorithms to apply to broad patient populations.

Martin also described his work in epidemiology/population health. He is developing models to determine the health impact of capital spending (e.g. including health assessment into environmental assessment.)

In terms of IT, Martin hopes to be in on a project to develop an EPR for blood analysis. He has also evaluated the use of a web management tool to make service recommendations to community pharmacies.

François Sainfort then asked the group to speculate on what could be done to improve NHS.

Ruth Davies argues that the system is subject to constant change in trying to make improvements. This sometimes eliminates good things. As a result, workforce morale and dedication have decreased. Workforce morale has decreased because of irrelevant paper work, requirements to supply useless information, and the eroding quality of the workforce. As an example, Ruth Davies feels that doctors now appear to be much more interested in money rather than giving selflessly to help the system.

Steve Gallivan argues that a lot of effort is now spent on spin. Steve would like to see a systems model in place. Every time a new policy is planned, it could be tested with this model. For example, the impact of European working rules (under which residents will be required to work no more than 55 hours per week) is a policy that is likely to have a significant impact that was never fully planned for.

Ruth Davies thinks enhancing GP services is necessary to improve NHS. Currently, the system includes incentives to pass along patients to consultants. This is detrimental to both cost and quality of care. Ruth feels the system could be enhanced by instituting a fee for service payments for GPs.

Martin Utley indicated that it is important for NHS to decide what it is all about. Consumerism is increasing in the U.K. and is having an impact on health care as patients demand more choice. This increases cost, but does nothing to increase funding. Martin feels there has to be some acceptance that NHS cannot do everything. At present, NHS is more of a wish list than a plan.

Sally Brailsford, like Steve Gallivan, argues for OR models to evaluate impact of policy change at the strategic level. She believes that the system can only be planned appropriately if a systems view is taken. At present, current policies are very political and are not subject to much analysis. Sally believes an integrated model for policy evaluation is within the realm of possibility and points out that similar models exist in the areas of Treasury and Transport.

Ruth added a note of caution, indicating that very large models are subject to error, since they do not always include behavioral aspects of individuals.

The NSF group asked the U.K. group to comment on how the research agenda is set.

A general discussion indicated that there is some mix of curiosity-driven and sponsored research. Approximately 10% of the research agenda is investigator-driven, with the remainder coming from sponsors.

Priority lists are announced by the DoH and, to a lesser extent by NHS. Most of the priorities are politically motivated. The U.K. group had mixed opinions concerning the appropriateness of politically driven research. Most felt the role of government included the right to set priorities; if such priorities are to be in place then evidence-based research is appropriate. However, when new policies and priorities are announced, researchers have to scramble to adjust their research agendas to fit the new mandates.

Steve Gallivan indicated that CORU is sometimes consulted as part of the research priority-setting process.

**Site:** Erasmus University  
**Institute for Health Policy and Management (BMG)**  
**Woudestein Complex, Burgemeester Oudlaan 50, 3062 PA**  
**Rotterdam, Netherlands**

**Date Visited:** November 5, 2003

**WTEC Attendees:** D. Gupta (Report author), T. Bartolucci

**Hosts:** Dr. Jan Vissers, Professor, Health Operations Management, Eindhoven University of Technology, Tel: +31-40-247-3937, Email: J.M.H.Vissers@tm.tue.nl  
 Dr. F.F.H. (Franz) Rutten, Professor, Health Economics and Management, Tel: +31-10-408-85-52, Email: f.rutten@bmg.eur.nl

When the meeting was originally scheduled, Dr. Luc Delesie (Leuven) and Professor Johan Mackenbach (Department of Public Health, Erasmus) were also expected to attend. Both could not attend due to other engagements.

### SUMMARY OF DISCUSSION

Professor François Sainfort asked Dr. Vissers to explain his past and current research, and the research done by others in the Netherlands that he might be aware of. As part of this question, he also asked Dr. Vissers to explain how the health care delivery system is organized in the Netherlands so the panel members could understand which research topics are not relevant to the U.S. health care delivery systems. Other questions were posed to Dr. Vissers. What are some emerging challenges for the Dutch health care system? Where in his opinion could engineering and mathematical sciences contribute the most? Who funds health care OR studies in the Netherlands? What is being done in terms of educating professionals and future researchers? What are the significant research questions for future studies?

Dr. Vissers responded by describing his background first and then making four brief presentations. The first presentation introduced the Dutch health care system. The second described networking among the research community in Europe through the European working group the Operations Research Applications in Health Services (ORAHS, available on the web at [www.soton.ac.uk/~orahsweb](http://www.soton.ac.uk/~orahsweb)). The third explained his past and ongoing research in terms of a framework for health care operations management that he has developed, and the fourth dealt with specific research projects that he is working on. He also answered questions from the panelists during his presentations. What follows is a summary of these presentations and ensuing discussions. In some cases, it was not possible to write down all the details from the power point presentations. The power point presentations should be consulted for that purpose.

Dr. Jan Vissers is trained as an Industrial Engineer and Management Scientist. He has been associated with the Eindhoven University for over 10 years on a 2/5th full-time equivalent (FTE) basis. He spends his remaining time with Prismant, a non-profit research and consulting company based in Utrecht, where his work has greater emphasis on projects that try to fill the gap between theory and practice. He is in the process of moving to Rotterdam's Erasmus University, where he will devote two-fifths of his time. He will continue to spend his remaining time at Prismant. Dr. Vissers joined the EURO group on health applications about 15 years ago and is the current president of that group.

Dr. Vissers emphasized that his work to date deals with health care operations management (OM), as opposed to health care operations research (OR). He sees a clear difference in these two approaches. Whereas OR is problem driven, OM takes the managerial perspective. It maps the process first and identifies the central control issues and control levers. Only then does the researcher focus on the problem-solving techniques.

Dr. Vissers mentioned that he has an applied OR background and that Eindhoven University has a strong research center on OM applications in production and logistics. In fact, he is a part of that group applying OM techniques to health care. He also mentioned that with the exception of the U.K., OR is not recognized in Europe as a relevant discipline by researchers involved in various aspects of health care. He added that in Holland people in health care do not understand what OR means and that most research relevant to the

WTEC study has been focused on logistics aspects of health care. However, there has been an increasing focus on applying OM techniques to health care.

Next, Dr. Vissers described two issues that he thought were particularly important for Holland. First, he felt that whereas the organization of networks of service delivery in health care had already occurred, this organization was not done from the OM perspective. He gave the example of coordination of “stroke services.” There had been an effort by the health care system to streamline services for stroke patients. However, this reorganization was done from the viewpoint of other disciplines (e.g., medical approach), but not from the operations management and logistics perspective. The second point he made concerned the balance between supply and demand for health services in the Netherlands versus other countries in Europe. He mentioned that wait lists were a growing problem in the Netherlands, but that wait lists and congestion were more serious problems in the U.K. and less pressing issues in countries such as France, Belgium, Germany and Austria.

The main points made in his presentation about the Dutch health care system are presented in bullet form below. Greater details can be found in the copy of his power point presentations (available from WTEC).

1. Prismant collects data for all health services in Holland. This data is available to researchers.
2. The Dutch system is a mix of public and private provision of services. GPs are independent service providers. Hospitals are also independent, private and non-profit entities.
3. Public universal insurance is provided to all citizens. It has two components. All exceptional medical expenses are covered 100%. In addition, necessary medical expenses are covered through one of two sources. There is a compulsory social insurance for low income (65%) and a voluntary medical insurance for the high-income persons (34%). About 1.6% of the population is not insured for necessary expenses. Insurance for less necessary care is entirely on a voluntary basis. Coverage varies widely.
4. Government does not provide medical services. It does, however, regulate the medical insurance and health care providers’ markets. It also aims to control the total expenditures on health care.
5. Cost containment strategies are planned both on the demand side and on the supply side. Holland spends about 8% of its GDP on health care expenditures. The expenditures are rising steadily at a mean annual rate of 3.6%.
6. Social insurance payments are deducted from payroll. All monies go into a central fund from which monies flow into different sickness funds (on a risk-adjusted capitation basis).
7. GPs are paid a capitation fee for each sickness-fund patient they care for and a fee for each service they provide to privately insured patients.
8. Hospital budgets are based on a complicated formula (it is not based on Diagnosis Related Groupings or DRGs). This formula takes into consideration the number of patients in the service area, the number of licensed beds, the number of specialists and the negotiated volume of output.
9. GPs act as gatekeepers. They are self-employed. Average panel size is about 2300 patients. Patients have free choice of a GP, but must enroll with a practice.
10. Consumers often demand specialist services immediately. In that case, they bypass the GP and go directly to the hospital emergency room. In order to provide after hours and weekend coverage, the GPs have organized to provide urgent care services linked to the emergency department of hospitals. Usually, in a city there are one or two locations where urgent care services are provided and a group of doctors are available for consultation on a rotating basis.
11. GPs specialize in the care of chronic patients. Only 6% of GP contacts result in referrals to specialists. GPs do not own hospital beds, but use diagnostic services at the hospital.
12. For-profit stand-alone specialist services are a fast-growing group within the health care delivery system, though they represent only 1—2% of services at the present time. Most specialists are affiliated with hospitals.
13. High-volume, high-efficiency service centers that focus only on certain limited types of procedures (e.g., knee and hip replacement) are also developing fast. This is similar in spirit to the development of diagnostic and treatment centers (DTCs) in the U.K.
14. Hospitals provide both inpatient and outpatient services. The health care provider market has seen a number of mergers lately, which has reduced the number of players and amount of competition in the market.

15. Waiting lists and waiting times have become a political issue. Waiting times vary quite a bit. For example, they are in the range of two to four weeks for general surgery and can be as long as 12 weeks for orthopedics. Hospital waiting times are tracked and can be found by visiting the web at [www.nvz-ziekenhuizen.nl](http://www.nvz-ziekenhuizen.nl) (in Dutch).
16. Hospital lengths of stay (LOS) have been declining. Average LOS has dropped from 14 days in 1980 to 7.7 days in 2000. Same day surgeries performed on an outpatient basis account for about 40% of all surgeries performed.
17. Major issues for the health care system in the Netherlands are:
  - a) Shortage of GPs and high GP workload.
  - b) Vacated GP positions in low-status suburbs.
  - c) Increasing wait lists.
  - d) Shortage of nurses.
  - e) Consumerism – patients demanding more services and direct access to specialists.
  - f) Restructuring of hospital insurance – moving to market competition.
18. Emerging new developments include the following:
  - a) Vertical integration and consolidation in the insurance and providers' markets leading to fewer players and lower competition.
  - b) Transmural care involving efforts to improve continuity of care. Issues addressed here are management of chronic diseases and greater collaboration between primary and secondary care.
  - c) A DRG-based system for hospital reimbursement. The system being developed is slightly different from the U.S. system in that it also includes fee for the specialist's services.
  - d) Consumer empowerment. Demand/need for making waiting time and other performance information about hospitals available to patients
19. Strengths of the Dutch health care system are
  - a) Good primary and secondary care
  - b) Patient choice (GPs, hospitals)
  - c) Cost containment
20. Weaknesses of the Dutch system are
  - a) Issues surrounding continuity of care
  - b) Workload of providers, especially GPs
  - c) Relatively weak consumers – result of the system that grew as a supply regulated system in which government played a key role in regulating the provision of health insurance and services

At this time, Dr. Vissers talked about the European working group on OR applications in health services. This group has been meeting for about 20 years. Each meeting has about 40 participants. Each participant usually makes a presentation and the meeting lasts one week. The format consists of 30-minute talks followed by some discussion. Typically, either conference proceedings or a special edited volume of European Journal of Operational Research (EJOR) is produced, consisting of papers presented at the conference. Dr. Vissers showed us some samples of the special issues and conference proceedings in previous years.

Next, Dr. Vissers summarized his own research in health OM by discussing the contents of a book he is preparing on health care operations management (co-edited with Roger Beech of Keele University and a publication of the Rutledge series on Health Management). The book focuses on patient flow logistics in health care. The major challenge for health care OM, in his opinion, is that processes in delivery of health care are not managed. These processes involve coordination between organizations and continuity of care remains an issue. Chapter 1 of his book presents the OM perspective and the need for managing processes; Chapter 2 deals with establishing the requirements of a production planning and control approach to health care; Chapter 3 defines the operations, processes and approaches – the latter can have unit, chain or network orientation; Chapter 4 is concerned with unit logistics and focuses on the optimal use of resources; Chapter 5 is concerned with chain logistics and focuses on optimizing the throughput of a chain; Chapter 6 is concerned with network logistics and here the focus changes to balancing service and efficiency to

provide the appropriate quality of care. A case study-based approach is taken in the book to bring out the main issues in Chapters 3 through 6. The conceptual framework is presented in the first two chapters.

Dr. Vissers talked about the overall conceptual framework, based on the hierarchical levels of decision foci that he formalizes in his book. These decision levels are as follows:

- strategic level decisions
  1. centralized versus decentralized
  2. contracted patient volume
- amount of resources available at an annual level
- time phased allocation of shared resources
- urgency and service requirements
- scheduling of individual patients

Dr. Vissers talked about several case studies that are in the process of being developed for the book. The conceptual framework was already developed in a series of papers he has written in the last few years, some examples of which are included below.

The first case study develops a map of various processes within each specialty of a hospital where the unit of analysis is a patient group that uses the same process pathway. Each specialty is modeled as a business unit managed by the specialists. In this case study, the hospital acts as a central decision-making organization that plans for capacity requirements at each node of the process.

The second case study concerns admission planning and case-mix decisions. The question here is to determine the ideal mix of patients that should be admitted each day of the week in order to smooth the usage of specialized resources and achieve the minimum threshold of patients in each category that need to be admitted each day to maintain good quality of service to all patient populations. This study utilizes a mixed integer programming formulation of the problem, which is imbedded in a decision support system.

The third case study develops a duty roster (rotation schedule) for specialists using multiple criteria. The model uses a simulated annealing approach, which is imbedded in a decision support system. The aim is to improve an existing schedule, rather than to find the optimal schedule.

The fourth case study develops business planning for surgical specialties by balancing wait lists and output. Wait lists exist for both inpatient and outpatient categories. In addition, a certain amount of capacity is consumed by emergency arrivals. The key question is how many patients in each category should be served? Typically, a common wait list exists for each specialty unless there are some highly specialized service providers whose services are not duplicated by others.

Dr. Vissers showed viewgraphs describing four other case studies. These dealt with the evaluation of priority-setting criteria and their implication on resources, allocation of resources on an annual basis in a hospital setting, modeling the interaction of resources within cardiac care units, long-term resource requirement planning at a hospital, and modeling the impact of service policy orientation in planning. The latter changes focus from resource utilization to service quality.

Dr. Vissers mentioned that the conceptual framework has been developed and that case studies are in the process of being developed. The handbook is expected to be ready for publication in 2004.

At this moment, Dr. Vissers was asked to comment on the extent to which the way of thinking about organizing health care delivery systems that he described in his handbook is widely accepted in Holland. Dr. Vissers felt that the OM approach is fairly widely accepted in the Netherlands. He also qualified that the book is aimed at practitioners, in particular hospital managers. He described briefly the educational program in health management at Rotterdam. The program has about 80 graduate and 200 undergraduate students. This topic was discussed in detail with Dr. Rutten who joined us at about this point in time.

Dr. Rutten explained that the Institute for Health Care Policy and Management operated as a subdivision of the medical faculty, but due to a reorganization, it is now an institute of the Erasmus University at Rotterdam. It is responsible for an undergraduate program in health policy and management and three graduate-level programs. The programs are in the areas of Health Economics Policy and Law, Health Economics, and Health Services Research. Of these, the first two are professional degree programs and the third program has a research orientation. In addition, there is a MS program in health information

management and a doctoral program in health care delivery. The institute also offers several professional development courses. For example, it offers a summer program for international managers, in cooperation with the Netherlands Institute of Health Sciences, which draws about 450 students each year.

Dr. Rutten drew attention to the increasing competition among European educational institutions. Many have started BS and MS degree programs whereas this split did not exist at European schools that historically offered a combined degree. In addition, there is a reciprocity agreement between schools in the European Union. Due to this agreement, students pay the same fee as they would pay in their own country and therefore are attracted to the school with the highest reputation. The Erasmus University has started a new International MS program this September that has 52 enrollees. Dr. Rutten also mentioned that there is a similar educational program in Maastricht, but which is smaller. The BMG has about 140 staff positions, of which between 15 and 20 FTEs are utilized in the educational programs. The remaining personnel focus on research. Most of the research positions are funded by research contracts.

There are three main foci of research at BMG. These are health technology assessment (HTA), structure and financing of health care, and organization and quality of care. The second stream deals with issues such as competition, insurance, the formula for allocating health care funds to different sickness funds based on health risk of the population served, etc. The third group is concerned with logistics and patient flow-type issues, quality and error prevention and reorganization of networks of health care delivery systems.

He gave the example of a technique developed by the third group to evaluate the stroke services program in terms of cost-effectiveness and quality and continuity of care. In addition, there is a subgroup that deals with the interaction between process management and information technology.

In response to a question by one of the panel members, Dr. Rutten talked about the disconnect between the inpatient and outpatient data. He mentioned that getting longitudinal data on patients is difficult. For these reasons, some data mining techniques are used. In some cases, manual data collection has to be done. In this context, it is useful to develop a supply chain framework. He also mentioned that an electronic patient records concept is being studied. He was not sure whether there were people at Rotterdam looking into this issue.

Dr. Vissers described a web-based system that was developed to track patient flows for cardiac care. In this system, each unit in the chain of care reported the patient arrival time, procedure time and departure time information via the Internet. This information was entered manually. The data is being used to study how the chain should be reorganized.

Both Dr. Vissers and Dr. Rutten were also asked to comment on how supply and demand are matched, particularly in hospitals. Dr. Vissers replied that this is hard to do and that the topic is too broad. He mentioned that in hospitals, beds are assigned to specialists and their numbers are calculated based on demographic information for each region. In nursing homes, beds are provided on the basis of utilization. These two systems of providing capacity induce different types of provider behavior. Whereas it is possible to find empty beds in the hospitals, the nursing home beds are always fully occupied.

Dr. Rutten added that the health care system in the Netherlands was in the process of transitioning from a regulated-supply system to a demand-driven system. A major difficulty in realizing a good demand-driven system is achieving equitable distribution of resources. Health insurance premiums are income-based, which are then allocated to insurance companies through risk-adjusted premiums. Individuals do not buy medical services directly. Government manages competition in insurance and provider markets. Many changes have occurred in recent years, but the changes have not been implemented fully, resulting in a system that is a complex mix of public and private insurance companies. The current budget deficit is putting the brakes on the deregulation process, which limits the insurance/provider competition.

Dr. Rutten talked about the importance of health technology assessment to the Dutch health care system. He said that HTA has always been of interest to the Dutch. In fact, whenever a new intervention is added to the list of benefits covered by insurance, it generates a need to evaluate the cost and benefit of the intervention. The interventions could be new screening programs, organ transplants, or new drugs or therapies. He clarified that the government specifies benefits only in the package offered through the public insurance, but it is customary for private insurance companies to follow suit, and provide the same package to the insured. In this context, Dr. Rutten talked about the increasing importance of drugs as drivers of health care costs. Prescription drug prices were not managed before 1991, when reference pricing was

introduced. Since 1997, the government has been involved in setting prices for pharmaceuticals. This system is similar to the Canadian and Australian systems. Pharmaceutical companies must submit information about a new drug before it is adopted in the formulary.

HTA is carried out in the Institute for Medical Technology Assessment (IMTA), which is a part of the BMG. It has about 25 staff members who work on contract research. This is a relatively large group in the European context. Other similar groups exist at York and Sheffield in the U.K., and in Germany. These groups compete for funding from the EU and drug companies (mostly American companies). Another source of funding comes from the need to carry out a cost-benefit analysis of new programs in the Netherlands. The funding for such evaluation is about €10 to 20 million. At the end of each pilot program, new policy guidelines need to be issued and this generates work for the IMTA. There is a proposal to set up a national level institute similar to NICE (National Institute for Clinical Excellence) in the U.K.

The next set of comments by Dr. Rutten and Dr. Vissers concerned the funding situation for research in the Netherlands. The government provides funding to a central research organization, which funds both medical- and natural sciences-oriented research. The research organization formulates programs (or themes) around which funding is provided. Until recently, planning issues in the delivery of health services have not been a part of any program. Program evaluation- and cost-effectiveness-type studies have been funded. This is changing and some recent small grants have been made to studies focusing on planning and organization of services.

Dr. Vissers described the set-up at Eindhoven where there is a school for production and logistics. This receives monies from the University as well as from the central research organization. The research school uses this money to hire staff as well as to pay stipends to doctoral students. The funding of the research institute at Erasmus is different and comes largely from contract research. PhD students are paid in part from institutional funds and in part from contract research funds. Thus, joining a doctoral program is similar to accepting a job at the University.

Methodology-oriented projects are also carried out by faculty involved in technology assessment. In fact, they are quite popular with research staff. For example, IMTA has been involved in the development of a measure for health status called Euroqual (similar to Qaly) and in the assessment of utility. However, a majority of the projects involve cost-effectiveness analysis. They are funded by the pharmaceuticals companies. At this point in time, device manufacturers are not required to demonstrate effectiveness of their inventions and such interventions are usually not evaluated in the same way as drugs are evaluated.

Dr. Rutten commented on the techniques used in health technology assessment. He mentioned that the cost-benefit analysis lies at the core of the assessment and that it may be organized along with a clinical trial. In other cases, assessment may use available data and perform a modeling study of effectiveness. There is a widely accepted methodology for carrying out these studies and several textbooks can be found on that topic.

At the end of this session, Dr. Vissers described some of his ongoing research. These are projects that he is carrying out at Eindhoven University. Some topics being studied are as follows:

1. Integrated planning of operational processes for the ophthalmology specialty in a hospital. This involves planning for different types of patients, e.g., cataracts and others, as well as being able to use a DRG-type compensation system as a basis for planning.
2. Logistic control of multi-symptom vascular disease patients. About 40% of patients have comorbidity factors. The question is how to organize services for these types of patients.
3. Impact of different types of production control strategies. For example, should elective patient procedures be booked and how far in advance?
4. Admission control under multiple resource constraints.

He described the main focus of his research as planning. That means specifying a sequence of events (process) and appointments for patients. The goal is to first classify patients into groups based on a common process sequence (these could be medical inhomogeneous sub-populations). Next, an appropriate plan is developed for each process homogeneous group of patients. This plan may specify patient appointments several weeks into the future (which helps patients), or offer services at a much shorter notice in response to dynamically changing available capacity. The latter approach is used when there is a great deal of uncertainty in capacity usage or in process sequence. At the higher level, planning also includes

resource constraints. The planning approach requires doctors to agree upon the criterion used to classify patients.

A second focus of his research is hospital production control. This centers on the comparison between different control strategies, e.g., choosing the amount of capacity to reserve for emergency patients.

**Site:**                   **Laboratoire Génie Industriel (LGI)**  
**École Centrale Paris**  
**Grande Voie des Vignes**  
**92295 Chatenay-Malabry Cedex, France**

**Date:**                   November 20, 2003

**WTEC Attendees:**   F. Sainfort (Report author)

**Hosts:**                Professor Yves Dallery  
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## SUMMARY

Professor Yves Dallery has been at École Centrale, a new school, for about four years. He is currently the Chair of the IE department. His group's main activity is operations management applied to manufacturing and supply chain management. However, there is willingness at École Centrale to consider applications in service operations. In particular, he and his colleagues are interested in health care delivery systems. Similar interest also exists in other parts of École Centrale.

Professor Yves Dallery's most recent project in the service operations area deals with call center management. He has been working with a company that is a major provider of mobile services in France. He advised one MS student about three years ago, whose master's project was on scheduling surgery rooms in a hospital. This work was well received by hospital administrators. Unfortunately, since then he has not done any new projects directly in the health care area. However, along with a doctoral student, he is just starting a major health care related project. He mentioned that it concerned an issue that is not included in the list of questions WTEC provided to the hosts. The problem deals with operational planning for home care services in France. There is increasing awareness in France that having people stay in hospitals before and after hospital procedures and during the palliative care phase is costly and less desirable from the patient's point of view. An alternative to this approach is to have patients stay at home and bring some services to their homes. The question is whether home care is medically feasible, safe and economical.

He thinks that whereas the first two questions are for the medical professionals, the cost-effective planning for providing such services is clearly an IE/OR/OM problem. Issues that arise revolve around cost and service quality. He gave the example of prescription drugs. How should these be delivered to home care patients? Should there be direct delivery from a local pharmacy? Should the delivery come directly from the hospital, or is it better to position warehouses that supply pharmaceuticals to patients in a region? How should visits by medical professionals (MDs, nurses) be organized? He also gave the example of palliative care for cancer patients. Can such care be made cost-effective if the patient stays at home? What services are needed? Which health care professionals and how many resources are needed?

École Centrale wants to have a research presence in the health care area. A new interdepartmental institute for biotechnology and health care has been started. One of the two managers of this institute is an engineer who is connected with the health care delivery organizations and has an understanding of what engineering can offer. The home care project will be affiliated with this institute and funding will come from regional social security funds. The student who has started working on this problem has her own fellowship and is already supported.

Professor Dallery mentioned that in order to do good research in health care, OR researchers need to spend time in health care delivery organizations to understand delivery processes, major issues, and constraints. He commented that health care-related papers often have good OR, but are of little value to health care professionals. It takes longer to produce usable results. He mentioned that his student is looking at prenatal care as the first type of home care service that could be provided on a pilot basis.

Professor Dallery is scheduled to meet with other French IE department colleagues on December 5th and volunteered to bring the research study questions to this group. He has offered to provide us with a brief

statement of any health care-related OR work being carried out and names plus contact information of key individuals involved. He is at present not aware of other researchers/groups working in this area, but suspects that there are some people who are applying mathematical/engineering approaches to health care.

Professor Dallery was next asked to comment on the awareness of OR tools and availability of research funding for health care OR in France. He thought that until recently, folks in the ministry of health did not have any idea of what OR/OM/IE can offer. However, this has been changing in recent years due to the emphasis on cost containment. He felt that the potential users of OR/OM methods do not fully understand the tools that are available, but that such awareness is less important than recognizing the value of OM/OR-type analysis. He feels that a lot can be learnt/applied from successful techniques developed for manufacturing management since the fundamental issues – cost, service quality, and timeliness of delivery, remain the same.

The NSF equivalent in France is called CNRS, which translates in English as National Center for Scientific Research. This agency funds research in IE/OR. Some health care projects are also funded within the IE/OR program. At the time of evaluating applications in Healthcare, this group seeks some validation from evaluators in the medical programs. However, in Professor Dallery's opinion, the medical group has not funded research involving the use of OR methodologies to health care systems. Overall, Professor Dallery feels that a very small proportion of total research funding is targeted at health care applications.

In this context, Professor Dallery also mentioned that IE is only now being recognized in France as a discipline at the National level. Until recently, IE faculty resided in ME and EE (automation/control) departments. Most IE/OR type research is funded by companies and not by CNRS. He mentioned that European Commission is also a major source of funding, but that he did not know whether or not they funded health care research and to what extent they did.

In closing, Professor Dallery also provided reference of an Italian colleague, Professor Andrea Matta from Polytechnic de Milano, who is working in the health care area. Diwakar Gupta will follow up and report if new information about research activities in Italy becomes available.

**Site:** **Katholieke Universiteit Leuven**  
**Ctr voor Ziekenhuiswetenschap**  
**Kapucynenvoer 35, B-3000 Leuven, Belgium**

**Date:** December 10, 2003

**WTEC Attendees:** J. Blake (Report author), D. Gupta, M. Carter, T. Bartolucci

**Hosts:** Lucas Delesie, Professor, Faculty of Medicine, Department of Public Health,  
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## SUMMARY

The system in Belgium is similar to the systems in Germany and France. Luc indicated that there is a system of compulsory insurance for all individuals in Belgium, funded by payroll taxes. (Luc indicated that 102% of all Belgians are currently insured.) Almost all health services are covered. The monies are distributed to six private insurance funds to pay for services (fully) as well as to hospitals, elder care centers, etc., to fund infrastructure (partially). Regional authorities provide additional infrastructure subsidies; when new hospitals are built, 60% of the capital comes from the community and regional authorities, while the remaining 40% (plus extra amenities) is raised locally. Some private, supplementary insurance exists to cover additional expenses related to private rooms, glasses, dental care, etc.

Administrative costs to insurance firms are made primarily via capitation. Hospitals are funded on a global budget basis using a consensus formula (more on this later). Physician services are reimbursed by the insurance companies on a fee-for-service basis. Most physicians are paid directly or through group practices with pooled funds (some general practices and most hospital physicians) or through wages (teaching hospitals). Rates for physician services are jointly negotiated by the insurance funds, the employers' associations, the various professional bodies and the (supervising) government. Hospitals and physicians have caps on the total number of procedures as well as limits on fees for some of the services they deliver. Caps exist for services such as inpatient days, laboratory tests, and antibiotics for surgery patients. If the caps are exceeded, sliding scales are used to reimburse for additional services or the overruns are recovered the following budget year. A small number (~10%) of physicians in private practice may charge any fee they like.

Hospitals are all not-for-profit organizations. Ownership is either public (local) or private; ownership is split approximately in half between religious and lay organizations (i.e. civic, universities). There are still two regional mental health facilities in Flanders. There has been a trend in public hospitals privatizing through networks of civic institutions or by merging with private hospitals. There is some variation in the hospital management between Flanders (North) and Walloon (South). The Flemish population is more strongly in favor of private hospital ownership than is the Walloon population. Luc noted, however, that issues of supply, demand, and capacity are similar in both the north and the south of the country. Of course, while the issues are the same, the approaches to cope with them differ.

The community (French-, Dutch- and German-speaking communities) and regional authorities (Flanders, Wallonia and Brussels) have decisive influence over hospital planning. Communities decide on the number of hospitals and their location, the number of practicing physicians, the number of funded seats in professional training programs, and even have some say in organizational accreditation.

Health care services are, for the most part, over-supplied in Belgium. There are some shortages of community services for the elderly (i.e. homecare) and waits are not unknown for new and expensive diagnostic treatments. However, doctors and hospital beds are in plentiful supply. Luc noted that there is a general prohibition on the over-prescription of antibiotics, but this still takes the form of guidelines to physicians rather than a formal rationing process.

John Blake then asked Luc to describe his research in the past and the present.

Dr. Delesie indicated that he was affiliated with an important Belgian Hospital Federation until 1993. He worked in elder care, mental health, and acute care. His work involved strategy, planning, capacity, and financing. He developed and helped with the implementation of a reimbursement scheme for elder care in

1982. He has been active in developing a hospital financing scheme that determines a hospital's budget. The formula includes a variety of parameters including volume and case mix (Diagnosis Related Grouping or DRG), and type and volume of nursing care (since 1987). Luc also did work to transfer his measurement and financing model to the mental health sector, but notes that progress is slower and that he retired from that particular field of mental health.

Dr. Delesie indicated that he is greatly interested in aspects of measurement. Specifically, his interests relate to finding reliable measures of performance and developing appropriate indicators for health systems. This is not a simple problem, since appropriate measures may not always be on a numeric scale. Accordingly, his research investigates methods for deriving methods to develop appropriate non-numeric scales and to reach federal consensus on them. He notes that a variety of techniques are used including Item Response Theory (IRT). Luc reminded the panelist that non-physical measures are always culturally and temporally based. In Belgium it is important to develop a consensus for measures that are acceptable to both the Flemish and Walloon populations and across different organizational settings (e.g. home care, nursing home and hospital care for the frail elderly). In addition to language issues, religion, ownership, and provider interests must be balanced within the Belgian system. When pressed for an example, Luc noted that his work in measurement forms the basis for the formulas used to determine elderly care budgets and contributes approximately 10% to the determination of hospital budgets. While most of the indicators used in the formula are process based in the acute care example, approximately 10% are based on ordinal or non-physical data.

Luc continued with his discussion of measurement, stating that he is very interested in determining measures for difficult to quantify items such as need, dependency, severity, qol, performance, professional competency, etc. These very personal concepts are very local and are influenced by culture and timing. To illustrate this point, Dr. Delesie described a discussion he had held earlier in the day with an Irish student. He noted that perceptions about palliative care in Catholic Ireland were likely to be very different from those in England or Scotland even if the language in all three countries is (about) the same. Dr. Delesie went on to describe his work to set appropriate measures for elderly care. He noted, in this instance, that it is important not only to meet the needs of both the north and the south of the country, but also to incorporate the wishes of home care and institutional providers. Luc concluded by noting his measurement work forms the basis of the financing formulas for elderly and acute care. He is working to bring the same framework to mental health, but noted mental health is a tougher problem, requiring substantial groundwork. In the mental health field a great deal of work must be undertaken to set a common language (i.e. should ICD-10 coding be adopted). In addition, conditions in mental health are more difficult to quantify. When, for example, is a person's depression or drug dependency 'cured?'

In addition to his interest in measurement, Dr. Delesie is also interested in applications of visualization (e.g. feedback and communication). He described the importance, for consensus building, of deriving concise information from a disparate dataset and presenting that information to decision makers in an easy to understand format. (An example of Dr. Delesie's visualization work can be found in his presentation at the 2003 ORAHS conference in Prague, which appears at the end of this site report.)

The panel then asked Dr. Delesie to comment on other OR research in health care in Belgium.

Luc indicated that OR Health Services groups exist at both the University of Leuven (Flemish) and the University of Mons (French). The Mons group is just starting to branch out into the field. The Leuven group has an established reputation within the Center for Health Services, while the Department of Applied Business focuses on traditional OR techniques (wait lines, queues, simulation, etc.) but has a number of students who produce MS-level theses on health services topics. Dr. Delesie indicated that the composition of the students coming through this program is quite varied. His class complement includes approximately 35-50 physicians, 35 health care managers, and 42 nurses. All students get an introduction to the domain. Some do thesis work that includes an OR component. Dr. Delesie supervises a number of students and has co-supervised students along with colleagues from the economics department.

The panel inquired about Health Technology Assessment in Belgium.

Luc indicated that a group is presently being established and is now hiring staff. He does not feel that the Belgian program will operate entirely on its own. Rather he anticipates strong cooperation with the French and Dutch HTA groups.

Diwakar Gupta asked about research into bio-terrorism or bio-threats.

Luc indicated that there is no bio-terrorism research in Belgium. It is, he feels, an American issue. A civil defence program is in place that undertakes exercises, but there is no research component to these activities.

John Blake asked Dr. Delesie to comment on the state of IT in Belgium.

Luc indicated that the government is interested in the concept of electronic patient records and is itself continuously in the process of redesigning its data warehouse. He indicated that a federal data collection program is in place and that all institutions are required to submit data in a prescribed format (i.e. a minimum data set). He also indicated common coding practices have been adopted across institutions and there is some indication that common standards will be adopted for medical records at some time in the future.

Dr. Delesie indicated that basic information systems are now in place. All institutions collect and contribute towards a national dataset. As an example, he indicated that nursing care data has been collected since 1987 and that efforts are underway to expand the dataset to include a more detailed breakdown of nursing care by type of care program (i.e. geriatrics, ICU, etc.).

Most physicians (~90%) have PCs and are able to collect and transmit data. He noted that automatic prescription generation, requisition of and feedback on laboratory tests is common, and that Picture Archiving and Communication Systems (PACS) to the general practitioner (GP) is just starting. As an example of information interchange, Dr. Delesie indicated that physicians are now able to view their patient's radiology results online. Luc indicated that data interchange is possible within the Belgian system because of the large IT influence of the National Insurance Agency and the regulating government and the emphasis on uniform medical records dictated by a number of professional groups.

Data exchange is also possible between hospitals and between hospitals and GPs. Luc indicated that approximately 80% of hospitals are able to send discharge notes to GPs via electronic means. Networks are currently developing that will enable GPs to access full hospital records.

Mike Carter asked if a unique patient identifier is assigned.

Luc indicated that a unique 13 digit patient identifier has existed since 1986 and that the list of insured persons is reviewed annually by the National Insurance Agency. It is now being used for all social program reporting. Interestingly, insurance agencies are allowed to choose their own identification numbering system, so long as it is unique. The number is thus similar to a SSN in the U.S. Using this unique identifier it is possible to trace patient movement through the health care system; Dr. Delesie noted that no single data repository exists, however. He believes that it would be impossible for historical reasons.

John Blake asked Dr. Delesie to comment on the state of chronic care in Belgium.

Luc indicated that there substantial initiatives in chronic care are underway. He gave home care, day care, and short term-care as examples of chronic care initiatives. His involvement in these programs is primarily in the area of developing and setting indicators, as well as creating financing formulas. Reiterating his earlier point, Dr. Delesie indicated that it is important to seek consensus for the metrics used to evaluate and finance chronic care.

Dr. Delesie also discussed mental health initiatives. At this point, he sees the mental health initiative as a program to design and organize care plans. This is an important part of making improvements to mental health care delivery, but it may not be an OR-intense application. Dr. Delesie has already organized the data flow to collect information needed to build a financing formula. Data collection is up and running, but information retrieval is still in the early stage. Luc notes there must be greater experience with the data before people start to debate its meaning.

John Blake asked Dr. Delesie to comment on work in epidemiology.

Luc indicated that there is a substantial epidemiology program in place. As examples, Dr. Delesie sited work in flu spread and vaccination models, as well as breast cancer detection models.

The panel then asked Dr. Delesie to comment on funding sources for research.

Luc indicated that funding comes from the federal government mostly in the form of project grants. The Ministry of Health announces a competition and invites researchers to bid on the projects. Dr. Delesie noted the political nature of the priority-setting process. He also reminded the panel that under EU rules, competition is open to everyone from the EU. Typically, however, grants go to Belgians at least in part because the language of communication must be either Dutch or French. On occasions, research consortiums are formed with researchers from outside Belgium, mostly with researchers from France or the Netherlands.

The meeting concluded with the comment from Dr. Delesie that a great deal of work remains to be done in health care. Luc noted that no one has found the golden bullet, yet.

### **Abstract of Luc Delesie presentation at ORAHS, Prague, Summer 2003**

How to Take into Account the Expectations & Preferences of the Clients in Elderly Care

Lucas Delesie

Catholic University Leuven

#### **Abstract**

The WHO demands to take into account the expectations of the elderly since 1973. Everybody agrees but few do it: The problem indeed is how? Most organizations, managers, ministers try to measure the prototype, average, model or robot client and to organize and deliver their services accordingly. This case study focuses on the sharp and exact measurement of the client and non-yet clients preferences with respect to a range of existing and future services. It shows how the managers can gain insight and develop knowledge and priorities for their strategy 2010 and program development along the road. The case covers the KBG, the largest Belgian organization for pensioners and its ongoing action plan for the years ahead.

**Site:** **Lancaster University (By telephone)**  
**Management Science Department**  
**The Management School**  
**Lancaster LA1 4YX, U.K.**

**Date:** Nov 26, 2003

**WTEC Attendees:** John Blake (Report author)

**Hosts:** Dr. David Worthington, Professor, Management Science, Tel: +44 (0)1524-59-3872,  
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## SUMMARY

Dr. Worthington indicated that he has been working in the area of OR/OM and health care management for the past 25 years. Over this period he has been involved in numerous lines of research. During this time he has dropped some lines of research, and continued others.

Dr. Worthington expressed an on-going interest in wait list management issues and appointment scheduling systems. In the past several years, he has had a great deal of interaction with NHS, mostly in the area of wait list management. Recently this has included work with the Modernization Agency. He noted that the Waiting List Team of the Modernization Agency has two people active in OR; these individuals report to the Leeds-based OR group, but have the Modernization Agency as their primary focus.

Dr. Worthington describes efforts by the NHS Wait List Initiative as being focused on encouraging good wait list management practices in hospitals (e.g. forming a single wait list for services). NHS is promoting this initiative which is about bringing out good ideas based on OR principals, implementing them at a local level, and then publicizing success stories. Dr. Worthington listed as an example, a scheme called Clinical Prioritization. This is an effort to get clinicians to set priorities for their patients and then to treat patients in first-in first-out (FIFO) order to achieve clinical goals.

John Blake asked about the scope of the Modernization program. Is it limited to London or is it a broader initiative?

Dr. Worthington indicated that the Modernization initiative is a broad, system wide initiative. There are several projects within the initiative (for example, radiology services), but the projects potentially encompass the entire NHS. Projects are sponsored by teams that go out to local hospitals and apply concepts to the area of interest. By focusing on local issues, the team gets buy-in. Once projects are underway, the team gathers success stories and publishes them to promote dissemination of ideas.

John Blake then asked if projects, such as the Wait List Initiative, fall under the rubric of the NHS R&D program or are strictly the focus of the Modernization Agency.

Dr. Worthington indicated that the Modernization Agency is the sponsor and promoter of the Wait List Initiative. The Agency uses individuals in a consultancy role to undertake projects. Included in the Agency's staff complement are two individuals with an OR focus who provide modeling support.

Most of Dr. Worthington's work with NHS takes place through graduate student projects. In the previous year, he was involved with two projects. One project was a "top-down" model, in which the student team developed a set of tools in Access and Excel to analyze nationally available data to identify Trusts with good (or bad) wait lists. The second project was a "bottom-up" approach to assist a local Hospital Trust in making use of Improvement Leaders' Guides. Improvement Leaders' Guides are documents that outline solutions to common operational issues. He noted that in many clinical environments, decision makers are simply too busy to take on the additional burden of operational improvement projects. This initiative gets around some of the initial learning curve in process improvement by inserting analysts to initiate a project. They involve hospital decision makers and do some education and training in OM techniques such as process mapping, quality control, and Business Process Reengineering (BPR). The team builds up expertise at the local hospital and guides them through the improvement process. Using success stories, the team develops guidelines for decision makers in other institutions who may be facing similar issues. The analysts disseminate the findings and act as a resource for individuals in other Trusts.

As an example of a project of this type, Dr. Worthington described recent work with ophthalmology wait lists in outpatient clinics. He noted that there are two general areas to deal with: the wait time within clinics and the backlog of cases waiting to gain entry to the clinic. Within clinics, wait times are best handled by improved appointment scheduling. Backlogs are a capacity management issue. He also noted that a certain amount of customization is always necessary when conducting an improvement project at a particular institution. Trusts may have unique characteristics that invalidate general improvement protocols or customization may be necessary to prove compatibility and to secure local buy-in.

John Blake then asked about the focus of research activities in the U.K. Is the majority of effort focused on health technology assessment? Is there a significant research effort in the area of operations management or operations research? Dr. Worthington acknowledged that there is a long and established program of research in the area of technology assessment. He noted that the work of people in Southampton to model disease progression was well-established and well-known. Efforts in this area have been promoted by national funding agencies. He also noted that research related to the field of health technology assessment is being undertaken in Sheffield and York. Researchers at these institutions have an interest in cost-effectiveness studies and have developed sophisticated modeling concepts. Dr. Worthington sees the work done at Sheffield and York to be a complement to randomized clinical trials. Some of the modeling techniques being employed include stochastic models, Bayesian analysis, and Monte Carlo simulation to evaluate cost-effectiveness over a range of uncertain parameter values.

Dr. Worthington pointed out a recent collaboration between the Universities of Sheffield and Lancaster. Each year, someone from Sheffield provides a lecture to Lancaster's graduate students, and for the last two years MS students have done projects with the Sheffield group (SchARR). This year, he has had a student working on Bayesian approaches to identify the value of perfect information for screening programs. In instances where conducting a full set of simulations on uncertain parameters is computationally daunting, other techniques for measuring a response surface must be developed. He described his student's work to create meta-models to estimate the response surface, which was combined with regression to estimate the value of perfect information.

Dr. Worthington returned to the idea of the differences between North America and the U.K. Engineers in North America tend to be more involved in operations work; technology assessment is the traditional domain of economists in North America.

Dr. Worthington highlighted the importance of applying OR at the strategic level. He noted the large number of issues crying out for a modeling approach. Operations researchers, he argued, bring a different perspective to problem solving and enhance the synergy of multi-disciplinary research teams.

John Blake inquired about the type of work that should be done in the future.

Dr. Worthington indicated that great potential exists in the area of simulation based models for hospital improvement. He doubts that any completely generalizable model can be invented, but suggests that decision makers are attracted to general improvement proposals. He feels a niche exists for customizable models that can be applied across a variety of institutions. As an example, Dr. Worthington described a simulation to determine if, or under what circumstances, booked admissions are a good idea. He also noted the importance for OR people to get a foot in the door when new policies are rolled out. Only by contributing to the development of these policies, can OR people hope to have an impact on the function of the system.

John Blake then asked Dr. Worthington to comment on research in IT. Dr. Worthington indicated that his experience with IT is as a user, rather than a designer. He uses IT systems extensively to build decision support tools for planning activities. He noted his recent work with Primary Care Trusts (PCTs) to undertake commissioning activities. Commissioning activities require PCTs to undertake a needs assessment and to compare a region's needs with the services actually delivered.

Dr. Worthington's work was funded by the Regional Health Authority, in conjunction with several local Trusts. The project title was Information Support for Healthcare Purchasing. His work involved consulting on the development and use of Geographic Information Systems (GIS) to compare service needs and service delivery. GIS systems, he noted, are particularly adept at bringing together a range of information. However, some knowledge of health care delivery is needed to create meaningful information from the mass of data available. His work involved pre-processing data prior to its import into a GIS to account for

population risk-adjustment and to increase the statistical power of the information coming from the system (i.e. standardizing admission rates).

John Blake asked about funding for projects.

Dr. Worthington indicated that much of his funding comes from the local Health Authority and local Trusts. He also noted that Lancaster has a program where graduate students complete projects in local firms. Students act in a consultant role on a project. Firms, in return, fund student positions. Students are closely supervised by faculty to ensure good results. In general, he takes on projects that come along with a health flavour.

Dr. Worthington has not tried recently to access funds via the NHS R&D program, although he has been undertaken regionally funded work of this sort. He notes that there is a regular flow of money through the HTA program and that it largely goes to researchers established in the field. New researchers may have difficulty accessing these funds. He also indicated that Lancaster is a pre-authorized research center under the NHS SD & O program.

John Blake asked Dr. Worthington to comment on OR education for health care professionals.

He indicated that education was primarily delivered through the school's graduate and undergraduate programs, and none of it is currently directly targeted at health care professionals. Lancaster provides a graduate degree in OR which includes a module on public sector management. Since most of the faculty within the stream is interested in health care, the module has a significant health care component. At any given time there are 40-50 graduate students in OR, of which 25-30 graduate and take the Public Sector Applications module. There are also 50-60 undergrads in training.

Education for clinicians (mostly nurses) is provided through a MA in Health Research. As part of this program, a course in Operational Research was offered and was well received. More recently, student numbers have declined and the course has been withdrawn. Dr. Worthington also has provided support for an HMBA offered through the University of Keele.

John asked Dr. Worthington to comment on work done in the realm of patient flow and capacity planning.

He noted that patient flow is a rich area of research; he plans to continue work in the area, noting that he has a real interest in problem-driven research. He highlighted his work in appointment booking systems as an example of the type of work in patient flow and capacity planning that he hopes to do.

Dr. Worthington suggested that capacity planning is always something of an issue in NHS. He noted that programs are frequently brought forward to address supply and demand issues. However, the fundamental problem of a mismatch between supply and demand is almost never addressed. Even if more money is thrown at the problem, odd results occur. For example, when capacity for a particular type of treatment is expanded latent demand appears and wait time is not seen to improve.

He also noted that he is more than happy to contribute to the macro problem of aligning supply with demand. Exactly how that should be accomplished is an open question.

Finally, John Blake asked Dr. Worthington if he could highlight the difference between the National Institute for Clinical Excellence (NICE) and the NHS Health Technology Assessment (HTA) program.

He noted that NICE tends to provide advice to physicians and managers about new and emerging technologies, often specific drugs or medical devices. The NHS HTA program looks at basic research into effectiveness and may involve technologies for which there is no commercial sponsor (i.e. surgical techniques) or technologies that have already been implemented.

## C. GLOSSARY

6th Framework Program	From the EU, a mechanism to fund and promote research
ANAES	National Agency for Accreditation and Evaluation of Health and Health Care (France)
BPR	Business Process Reengineering
CDC	Centers for Disease Control and Prevention (U.S.)
CDM	Chronic Disease Management (U.K.)
CEA	Cost-effectiveness analysis
CNRS	National Center for Scientific Research (France)
CORU	Clinical Operations Research Unit
DEA	Data Envelope Analysis
DES	Discrete Event Simulation
DFG	German Research Council (Germany)
DoH	Department of Health (U.K.)
DRG	Diagnosis Related Grouping
DTCs	Diagnostic and Treatment Centers
ECCH	European Case Clearing House
EHR	Electronic Health Record
EPA	Environmental Protection Agency (U.S.)
EPR	Electronic patient record
EPSRC	Engineering & Physical Science Research Council (U.K.)
EU	European Union
FIFO	First-in first-out
GIS	Geographic Information Systems
GP	General practitioner
Has	Health Authorities
HCFA	Health Care Financing Administration
HMI	Health Care Management Institute
HTA	Health Technology Assessment
ICU	Intensive Care Unit
IMTA	Institute for Medical Technology Assessment
Improvement Leaders' Guides	Documents that outline solutions to common operational issues
INSERM	National Institute for Health and Medical Research (France)
IT	Information Technology
LOS	Lengths of stay
LSE	London School of Economics
MoD	Ministry of Defence
MRI	Magnetic resonance imaging

NEAT	New & Emerging Applications of Technology
NICE	National Institute for Clinical Excellence (U.K.)
NIH	National Institutes of Health (U.S.)
OECD	Organisation for Economic Co-operation and Development
OM	Operations Management
OR	Operations Research
ORAHs	Operations Research Applications in Health Services
PACS	Picture Archiving and Communication Systems
PCGs	Primary Care Groups
RCTs	Randomized Clinical (or Control) Trials
ROC	Receiver Operating Characteristic
ScHARR	Sheffield group (U.K.)
SDO	Service Delivery and Organisation
Sickness Funds	Government-chartered non-profit corporations that serve the same function as private insurance companies in the U.S.
TQM	Total quality management
Trusts	Hospitals in the U.K. are managed by independent not-for-profit agencies called Trusts
UCL	University College London (U.K.)
UMIST	University of Manchester Institute of Science and Technology (U.K.)
WHO	World Health Organization

Operations research provides a wide range of methodologies that can help hospitals and other health care systems to significantly improve their operations. Kelle et al. [49] provided decision support tools that improve operational, tactical, and strategic decision-making supply chain management under an inventory. A brief review of operations research (OR) applications to healthcare system are addressed in this paper. The purpose of this paper is to identify the existing literature on the wide range of operations research (OR) studies applied to healthcare, and to classify studies based on application type and on the OR technique employed. Request PDF on ResearchGate | On Sep 1, 2013, Roberto Aringhieri and others published Operations research for health care delivery (Editorial). Patients are dynamic; they are added to the system and their health conditions change while they are in the system until the moment they are removed from it because of various reasons. 1-s2.0-S0167923616300860-main(2). Data. Operations Research for Health Care (ORHC) focuses on the development and use of operations research and analytics in health and health care. The journal publishes high-quality operations research and/or analytics approaches to problems in health care from researchers and practitioners. Review Papers: The content and presentation of this international journal is such as to provide maximum utility to researchers, teachers and practitioners who have an interest in operations research techniques for good health care delivery. Review papers will be presented from time to time, as deemed suitable.