CHAPTER 3
CAPACITY PLANNING AND PATIENT FLOW MANAGEMENT

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INTRODUCTION
Healthcare 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 that get 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 (outpatient) cases include short procedures (e.g., day surgeries) and consultation visits to specialty clinics. In contrast, non-ambulatory or 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 healthcare delivery systems in the countries surveyed.

Commensurate with the classification scheme described above, the provision of healthcare at the national level in the countries surveyed is often thought of in terms of the amount of healthcare spending on each segment of the healthcare 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. The 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 has become required lately by sickness funds in several countries surveyed. GPUs 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.

We can turn now to the first of the two major issues being explored in this chapter: capacity planning. 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. The remainder of this chapter is organized into three sections. The next section describes state of the art in capacity planning and patient flow management practices in each country. This is followed by a section that deals with ongoing and planned research projects. The final section summarizes our findings and concludes the chapter.

THE STATE OF THE ART

From the comments of researchers we interviewed, the following broad patterns can be identified. The healthcare 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 healthcare 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 a lack of data (with some exceptions in 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
Healthcare in Austria is organized by lander (state). There are nine states 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 the 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 shrinking, 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 such resources 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 nurse 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 (lander or states) 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 healthcare system. These are described in brief as follows.

The healthcare 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, 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 healthcare 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 healthcare 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 (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 healthcare is not done from the operations management (OM) 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 healthcare 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, 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., Checklist software; details are available on the web at 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.

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 the wait 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 a 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 or 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 the University of Vienna in 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 the elderly. She mentioned that at the strategic level, operations researchers can help address many of the emerging issues in healthcare including:

- How should the different parts of the healthcare 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 of Katholieke Universiteit Leuven, 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 healthcare 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, 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 Téboul developed some cases based on a Swedish hospital (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.

- Dr. Jon Chilingerian, with INSEAD’s Health Management Initiative, worked with a hospital in Leuven, Belgium, on the consequences of poor capacity planning. During a liver transplant it was found that no ICU beds were available with the result that the patient was kept in the operating room for 12 hours. This incident set 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 of INSEAD 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, Cryptosporidiosis, 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 Cryptosporidiosis 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 healthcare 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 healthcare delivery research to be a major future research activity for him.

Germany

Professor Busse of Technical University Berlin 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).

At the macro level, studies in healthcare need to focus on promoting entrepreneurial behavior, international health policy, the role of new technology and IT in healthcare, 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 of Erasmus University is completing a book on healthcare operations management, 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 healthcare; 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 healthcare operations management is that processes in delivery of healthcare are not managed. Such processes include coordination between different institutions, between ambulatory and non-ambulatory sectors of the healthcare 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 to 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, 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.

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 firsthand during a meeting with several researchers at CORU.

Professor Steve Gallivan, 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 identify 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 Gallivan, 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 Gallivan’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 Gallivan 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 Gallivan 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 healthcare 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 analyse 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, healthcare 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 healthcare 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 healthcare sectors; mostly notably the ambulatory and the non-ambulatory sectors. As a result, a system-level model of healthcare resources and patient flows is feasible and needed, but lacking.