Enhancing the effectiveness of health care for Ontarians through research

ICES Institute for Clinical Evaluative Sciences

Health Human Resources for Neurosurgical Services in Ontario

Recommendations for Neurosurgery, Complex Spinal Surgery, and Interventional Neuroradiology

ICES Investigative Report

June 2005

Health Human Resources for Neurosurgical Services in Ontario

Recommendations for
Neurosurgery, Complex Spinal Surgery, and Interventional Neuroradiology

ICES Investigative Report

Authors

Joshua Tepper, MD, CFPC

Cheryl Jaigobin, MD, FRCP(C), MSC

Catherine Wang, BSc, MHA, CHE

June 2005

Publication Information

Published by the Institute for Clinical Evaluative Sciences (ICES) © 2005

How to cite this publication
Tepper J, Jaigobin C, Wang C. Health Human Resources for Neurosurgical Services in Ontario. ICES investigative report. Toronto: Institute for Clinical Evaluative Sciences; 2005.

Institute for Clinical Evaluative Sciences (ICES)
G1 06, 2075 Bayview Avenue
Toronto, ON M4N 3M5
Telephone: 416-480-4055
www.ices.on.ca

Authors' Affiliations

Joshua Tepper, MD, CFPC
Associate Scientist, Institute for Clinical Evaluative Sciences

Cheryl Jaigobin, MD, FRCP(C), MSC
Assistant Professor of Medicine, University of Toronto
Neurologist, University Health Network

Catherine Wang, BSc, MHA, CHE
Manager (former), Corporate Planning, University Health Network

Acknowledgments

The Institute for Clinical Evaluative Sciences wishes to thank the following individuals for their key advisory role in the production of this report.

Provincial Neurosurgical Task Force

Chair—Mr. Tom Closson
President and CEO, University Health Network, Toronto

Dr. Brien Benoit
Chief (former), Neurosurgery, The Ottawa Hospital

Mr. Peter Biasucci
Manager, Priority Programs, Ministry of Health and Long-Term Care

Dr. Susan Brien
Chief (former), Neurosurgery, Hotel-Dieu Grace Hospital, Windsor

Dr. James Drake
Neurosurgeon, The Hospital for Sick Children, Toronto

Dr. Joel Finkelstein
Spinal Surgeon, Sunnybrook and Women's College Health Sciences Centre, Toronto

Ms. Brenda Flaherty
Vice President, Patient Services, Hamilton Health Sciences

Dr. Dennis Izukawa
Chief, Neurosurgery, Trillium Health Centre, Mississauga

Ms. Mary Catherine Lindberg
Executive Director, Council of Academic Hospitals of Ontario

Dr. Steven Lownie
Division Chief, Neurosurgery, London Health Sciences Centre

Dr. Rick Moulton
Division Head, Neurosurgery, St. Michael's Hospital, Toronto

Dr. F. A. Ogundimu
Chief, Neurosurgery, Sudbury Regional Hospital

Dr. Kesh Reddy
Division Head, Neurosurgery, Hamilton Health Sciences

Dr. Michael Schwartz
Chief, Neurosurgery, Sunnybrook and Women's College Health Sciences Centre, Toronto

Dr. Gaetan Tardif
Physician-in-Chief, Toronto Rehabilitation Institute

Dr. Rudiger Von Ritschl
Interventional Neuroradiologist, Thunder Bay Regional Hospital

Dr. Christopher Wallace
Division Head, Neurosurgery, University Health Network, Toronto

Dr. Sam Wiebe
Neurologist, London Health Sciences Centre

Dr. Charles Wright
Consultant/Advisor, Ministry of Health and Long-Term Care

Research Guidance and Critical Review

Mr. Tom Closson
President and CEO, University Health Network

Dr. Andreas Laupacis
President and CEO, Institute for Clinical Evaluative Sciences

Knowledge Transfer

Paula McColgan
Vice President, Policy and External Relations, Institute for Clinical Evaluative Sciences

Editor

Carolynne Varney
Institute for Clinical Evaluative Sciences

Layout

Shelley Drennan
Institute for Clinical Evaluative Sciences

Cover and Map Design

Laura Benben
Institute for Clinical Evaluative Sciences

About ICES

Ontario's resource for informed health care decision-making

ICES (Institute for Clinical Evaluative Sciences) is an independent, non-profit organization that conducts research on a broad range of topical issues to enhance the effectiveness of health care for Ontarians. Internationally recognized for its innovative use of population-based health information, ICES knowledge provides evidence to support health policy development and changes to the organization and delivery of health care services.

Unbiased ICES evidence provides fact-based measures of health system performance; a clearer understanding of the shifting health care needs of Ontarians; and a stimulus for discussion of practical solutions to optimize scarce resources.

Key to ICES' research is our ability to link anonymous population-based health information on an individual patient basis, using unique encrypted identifiers that ensure privacy and confidentiality. This allows scientists to obtain a more comprehensive view of specific health care issues than would otherwise be possible. Linked databases reflecting 12 million of 30 million Canadians allow researchers to follow patient populations through diagnosis and treatment, and to evaluate outcomes.

ICES brings together the best and the brightest talent under one roof. Many of our faculty are not only internationally recognized leaders in their fields, but are also practising clinicians who understand the grassroots of health care delivery, making ICES knowledge clinically-focused and useful in changing practice. Other team members have statistical training, epidemiological backgrounds, project management or communications expertise. The variety of skill sets and educational backgrounds ensures a multi-disciplinary approach to issues management and creates a real-world mosaic of perspectives that is vital to shaping Ontario's future health care.

ICES collaborates with experts from a diverse network of institutions, government agencies, professional organizations and patient groups to ensure research and policy relevance.

Contents

Chapter 1—Overview

Executive Summary

Issue

Neurosurgical conditions are a major cause of morbidity and mortality in the population, with high cost to the affected individuals, their families and to society. Diseases or injuries to the brain, spinal cord, peripheral nerves or muscles have a serious negative impact on the quality of life for patients and their caregivers. Many of these conditions are disabling or progressive and potential cures are not on the immediate horizon.

Diseases of the nervous system require a multidisciplinary medical model that includes neurologists, neurosurgeons, orthopaedic surgeons, interventional neuroradiologists, physiatrists and a broad range of other health care professionals specially trained in neuroscience. Highly sub-specialized teams, for example in integrated spinal programs, often provide the service.

In Ontario, **neurosurgery (NS)**, **complex spinal surgery (CS)** and **interventional neuroradiology (IN)** services are concentrated in university-affiliated academic health science centres (AHSCs): Hamilton Health Sciences, Kingston General Hospital, London Health Sciences Centre, St. Michael's Hospital, Sunnybrook and Women's College Health Sciences Centre, The Hospital for Sick Children, The Ottawa Hospital, and University Health Network. In addition, neurosurgical services are provided in four Ontario community-based hospitals (Hotel-Dieu Grace Hospital–Windsor, Thunder Bay Regional Hospital, Sudbury Regional Hospital, and Trillium Health Centre) that serve a less complex patient population. Patients are often referred from these centres to AHSCs.

Visible symptoms of stress in Ontario's delivery system for neurosurgical services include:

- Loss of Ontario's well-trained medical residents and fellowship graduates to the United States and other provinces due to the disparity in system resources;
- Increasing fiscal pressures that impinge on AHSC mandates to develop new technologies and practices are making ongoing research and development activities unsustainable;
- Reduced capacity with the closure of NS units in Toronto, St. Catharines, Kitchener and Waterloo, despite improved technology to help shorten lengths of acute care hospital stay;
- Unequal access to appropriate technology and care across the province, which is sub-standard to the North American and European norm;
- Variability in the provision of care that bridges acute and rehabilitation services, for example, the use of intrathecal pumps to control spasticity in spinal cord patients. Commonly accepted in most developed health systems, this intervention is offered sporadically in Ontario, and not at all in the Greater Toronto Area.

Patient types that may be inadequately served include those with acute rupture of cerebral aneurysms, vascular malformations of the brain and spinal cord, epilepsy, acute and chronic spinal diseases requiring surgery, and neurodegenerative diseases that have been shown to benefit from neurosurgical or neuroradiological interventions and rehabilitation.

Study

Focusing primarily on health human resources issues, the key objectives of this study were to:

1. Identify system-level medical staff and technology issues that impact on access to neurosurgical services, including NS, CS, and IN.

2. Make short and long-term recommendations to address these access issues, including funding recommendations.

The study describes:

- Types of services and providers;
- Current and future demand/supply of services;
- Emerging treatments; and,
- Current technology.

Five sources of data were used by the Institute of Clinical Evaluative Sciences (ICES) to help develop the health human resources model and predict future implications:

- ICES Physician Workforce Database (IPWD);
- Mail-based workforce survey sent to relevant physicians and administrators;
- Expert focus groups for NS, CS, and IN;
- Ontario Health Insurance Program (OHIP) database and Canadian Institute for Health Information (CIHI) database; and,
- Other health human resources data sources, such as the Ontario Medical Association's annual physician human health resources survey.

Key Findings

- All three key service areas studied, NS, CS and IN, in particular, are highly regionalized services provided in large, southern, urban and predominantly academic centres, and are delivered by a predominantly male and older workforce derived of neurosurgeons, certain orthopaedic surgeons, and selected neuroradiologists.
- Access to neurosurgical care is unequal across the province. Centralization of service delivery is largely due to high resource intensity, expensive infrastructure, and the small number of physicians providing the services.
- For the most part, need for NS and IN is being met. Conversely, only the most urgent CS cases are treated in a timely manner, and there is significant unmet demand for moderately urgent cases, with growing wait lists for even a first assessment by a CS surgeon.
- Timely access to interventional neuroradiology is limited because of the low number of centres providing the service.
- Although current demand is generally being met, it is mainly accomplished through a high workload divided among very few surgeons, which is not a sustainable strategy.
- Post-graduate training streams are limited.
- Five years following graduation, approximately 50% of Ontario neurosurgery graduates have left to practice in the United States or other provinces.
- An aging population and neurosurgical workforce will have implications on future supply of providers.
- The already very sub-specialized fields of neurosurgical sciences are becoming even more focused, which will pose challenges for staffing community-based hospitals.
- The frequency of on-call service duties is usually much higher than what is recommended by the Canadian Medical Association, and the on-call workload is very demanding.
- Coverage of neurosurgery on-call schedules has become very challenging in some hospitals due to an inadequate number of physicians.
- The three fields are highly dependent upon advanced, cutting-edge medical technology (including imaging and surgical devices). Survey respondents indicated limitations in access to what they considered important technology; these can be major cost centres in a program.

- There will likely be an expanding need for complex spinal surgery and interventional neuroradiology, which will be difficult to meet with current physician numbers and allocated resources (including diagnostic and treatment equipment).
- Growth in service demand is likely to be seen in spinal surgery for metastatic disease and interventional procedures such as coiling treatment for aneurysms, and neurosurgical services associated with diseases of aging, such as osteoporosis.

Implications

Study results can be used to help define health human resources needs and care models for improved delivery of, and access to, neurosurgical services across Ontario.

Introduction

Neurosurgery (NS) is a highly sub-specialized service for the treatment of patients with diseases affecting the brain and spinal cord, provided predominantly in large, urban settings (mainly in academic health sciences centres). Neurosurgeons typically train for six to eight years and face significant workload pressures in practice. Neurosurgical care is often acute in nature, with neurosurgeons facing "life or death" decisions, though elective surgical procedures that can dramatically impact a patient's quality of life are also part of the equation. Heavily technologically-driven, the field of NS sees introductions of new and improved devices and equipment each year.

Neurosurgical services funding is derived from the providing hospital's global budget as it is not currently a priority program of the Ontario Ministry of Health and Long-Term Care (MOHLTC). Thus, it is vulnerable to cutbacks related to budget deficits and significant associated operating costs.

Chiefly focused on health human resources issues, this report serves to:

1. Understand the complex, interdependent system pressures facing neurosurgical science specialties;
2. Highlight the need to stem the current erosion of neurosurgical science services; and,
3. Shed light on the expected and growing pressures that the neurosurgical sciences will face in the near future.

Detailed information and priority recommendations in this report have been provided to help strengthen the delivery of neurosurgical services in Ontario.

Background

Over the past few years, Ontario has reduced neurosurgical service capacity, with the exception of stroke treatment. This is largely due to program closures and reductions resulting from smaller hospitals' difficulty in sustaining a critical mass of service and expertise, and for other hospitals, budget cuts and increasing inflationary costs. Consequently, with reduced funding and infrastructure support, highly trained neurosurgeons have departed for other jurisdictions and recent graduates have followed opportunities outside the province, often to the United States (US).[1]

To address these stresses on service delivery, the Institute for Clinical Evaluative Sciences (ICES) embarked on a comprehensive year-long study of NS, complex spinal surgery (CS) and interventional neuroradiology (IN) services in Ontario, with assistance from the Provincial Neurosurgical Task Force, chaired by Tom Closson, President and CEO, University Hospital Network, and comprised of neurosurgical leaders from across Ontario. The key objectives of the study were to:

1. Identify system-level medical staff and technology issues that impact on access to neurosurgical services; and,

2. Make short- and long-term recommendations to address access issues, including funding.

The following analyses were conducted to help identify policy options for neurosurgical services for consideration by the MOHLTC:

- Overview of the health human resources situation and policy options (including technological impact) for current and predicted neurosurgical services in Ontario;
- Regional mapping of neurosurgical services to determine geographic utilization patterns;
- Dynamic modeling of different health human resource scenarios;
- Cost impact analysis of current and predicted neurosurgical services; and,

- Review of the literature and use of expert focus groups to determine current and predict future trends in neurosurgical services in other jurisdictions.

For information on the task force project charter, see Appendix A, and for a detailed description of the study methodology, please see Appendix B.

A distinctive theme emerged for each of the three sub-specialty areas studied:

Neurosurgery is the most well-defined of the three neurosurgical areas. This sub-specialty is facing a predicted shortfall in the number of practicing neurosurgeons. Current practice patterns are potentially unsustainable and anticipated changes in supply and demand will likely require more physicians to enter the system. The change in balance is being driven by several factors, including: physician retirement, greater participation in academic activity, shorter workweeks, increasing service demand from an aging population, and new or improved diagnosis and treatment techniques.

Complex spinal surgery is delivered by neurosurgeons and orthopaedic surgeons. Exact definitions and utilization information are difficult to determine due to lack of available data. However, long wait times are reportedly resulting in barriers to appropriate access.

Interventional neuroradiology is an emerging field provided almost exclusively by radiologists. In its current stage of infancy as a sub-specialty, there are relatively few providers and low volumes of services. However, there is potential for strong growth in demand, which will affect NS and CS practice patterns.

Neuroscience providers have observed the following:

- Four practicing neurosurgeons from a pool of approximately 70 left the province in the last 2–3 years. Furthermore, data from the Canadian Post-Graduate Education Registry (CAPER) indicates that Ontario loses approximately 50% of NS residents and fellowship graduates to the US and other Canadian provinces;
- Increasing workloads make ongoing research activities unsustainable despite the mandate of academic hospitals to develop, introduce and evaluate new technologies and practices;
- System capacity has decreased with the closure of NS units in Toronto, St. Catharines, Kitchener, and Waterloo and the shrinking of existing programs, such as Windsor and Sudbury, due to budget cuts and physician attrition;
- Coverage of NS on-call schedules has become very challenging in some hospitals due to an inadequate number of physicians;
- Sustainability of certain sub-specialties within neuroscience programs are at risk of closure with a lack of critical mass to maintain service and expertise (which also impacts ability to teach future health care professionals); and,
- Access to appropriate technology and care processes is unequal across the province.

Other recent reports and recommendations concerning neurosurgical services in the province submitted to the MOHLTC, include:

- *Recommendations for Improved Access to Neurosurgery in Toronto,* by the Toronto District Health Council (TDHC), August 2003;[2] and,
- *Achieving Stability for Neurosurgery in Ontario*, by Dr. Charles J. Wright, October 2003.[3]

The Toronto District Health Council (TDHC) review identified neurosurgical services in the Toronto area. Local system-level issues affecting access to neurosurgical services, and short- and long-term recommendations, were identified. Given that less than half of the province's neurosurgeons are concentrated in the Toronto area, access to these services throughout Ontario requires broader study. The Provincial Neurosurgical Task Force would build on TDHC's work for its provincial access evaluation, though with more narrow focus on medical staff and technology access issues.

In an effort to build on these reports, and recognizing the importance of attracting and retaining leading neurosurgical professionals, ICES focused its study predominantly on health human resources. This report serves to advance the TDHC report's Recommendation #4: *"That neurosurgical service providers undertake a provincial initiative to establish a planning and benchmarking ratio for neurosurgery specialists and develop a province-wide neurosurgery human resources plan."*

System capacity concerns regarding the neuroscience workforce have been identified and highlighted in recent years. For example, the Hugenholtz study of the NS workforce in Canada, published in the *Canadian Medical Association Journal* in 1996, predicted many of the current issues facing today's neuroscience providers. In particular, the paper highlights the need for strategies to address the chronic shortfall and attrition of established neurosurgeons, as well as increase and retain the number of Canadian NS graduates.[4]

Key Findings

Providers of neurosurgical services

For the most part, NS, CS and IN, in particular, are highly regionalized services provided in large, southern, urban and predominantly academic centres, and are delivered by a predominantly male and older workforce derived of neurosurgeons, certain orthopaedic surgeons, and selected neuroradiologists.

Centralization is a result of the resource intensity, as well as critical mass of specialized expertise, required to support a neurosurgical program of excellence. Expensive infrastructure is cost prohibitive for many acute care hospitals; NS and CS require dedicated technology for diagnosis and treatment, while IN requires catheterization suites affiliated with large radiology departments. The small number of physicians providing these services further drives centralization. Compared to Ontario's more than 10,000 family physicians, the neurosurgical workforce is very small, with less than 120 physicians practising in the three areas combined. Of these, less than two dozen provide IN.

In addition, neurosurgical services can overlap with those of other physician groups. For example, neurosurgeons and vascular surgeons perform carotid endarterectomies, while neurosurgeons, orthopaedic surgeons, plastic surgeons, and even some family doctors, perform carpal tunnel surgery. Future service overlap may grow with neurologists engaging in interventional cranial procedures and anaesthetists performing certain interventional spinal activities. Future service delivery is likely to reflect an increased sub-specialization of providers and blurred scope of practice among physician groups.

Current service demand and supply

Current demand

For the most part, need for NS and IN is being met. Physicians meet patient demand for NS through a several strategies, resulting in relatively timely access to services. Meeting IN demand depends on the availability of a supporting infrastructure and presentation of patients in a timely manner. Conversely, patients requiring the most urgent CS care are treated in a timely manner, but there is a significant unmet demand for moderately urgent patient cases. In many cases, the delay stems from the first assessment, resulting in lengthy wait times for patients that may not even be appropriate for spinal surgery.

Current supply

Although current demand is generally being met, it is mainly accomplished through a significant workload divided among too few surgeons. The average workweek of academic and community surgeons is 65–80 hours, not including on-call obligations.

The 2003 annual Ontario Medical Association (OMA) health human resources survey noted that neurosurgeons had the second highest hourly workload while oncall.[5] In addition to being very busy during on-call duty, neurosurgeons can be on-call as frequently as every other day, or for extended blocks of time (e.g., a week). Furthermore, community surgeons and interventional neuroradiologists are typically first on-call with no support from residents or fellows, and associated obligations are intensive, often requiring the physician to be on-site for much of the time.

Relief in the short-term, without direct and deliberate intervention, is not likely. Post-graduate training streams are small in number and fellowships are not funded by the MOHLTC, which requires reliance on a combination of other funding sources. In addition, due to their heavy workload, those already in practice have limited opportunities to train in new techniques.

Meeting demand by overtaxing the short supply of health human resources is clearly not a sustainable strategy whose consequences are contributing to current pressures on the health system. Without an infusion of more NS graduates, supported by an alternative funding plan (AFP), today's practicing surgeons may burn out, relocate or consider earlier retirement. Current demand would no longer be met and patients would wait longer for treatment.

Future service demand and supply

Factors that will drive demand

The aging population alone is predicted to cause an average increase in demand of at least 1–2% every three years for most neurosurgical procedures.[6] Additional population growth through immigration may push general demand even higher (estimated at another 1–2% every three years).[6]

Higher growth in demand is predicted in several specific areas, and information from new clinical trials has the potential to significantly increase demand 10–70% in the next decade. This includes the role of spinal surgery for metastatic disease[7] and particular interventional procedures such as coiling treatment for aneurysms.[8] Diseases linked with aging, such as osteoporosis, along with greater public expectations for quality of life in old age, will also drive certain neurosurgical treatments.[7]

Future supply

There is good rationale to suggest an urgent need to have more neurosurgeons and neuroradiologists enter the clinical areas NS, CS and IN. This is driven by a variety of factors including:

- Increasing demand for services;
- Greater complexity of care;
- Increasing need for specialization;
- Better balance between professional and personal life (reduced weekly hours);
- Better balance between clinical activities and other professional interests (e.g., research and teaching); and,
- Patient empowerment and the need to enhance patient communication and follow-up.

To meet the inevitable increase in demand, changes to training programs are likely needed to attract more neurosurgeons. However, this is a long-term strategy due to the length of time required to train a neuroscience specialist. A more immediate solution needs to be put in place to help alleviate current workload pressures, such as enhancing the roles and scope of practice for advanced nurse specialists in settings that include office assessments, operative events and post-operative care. There is also a role for other physicians, such as family physicians, to help in office or outpatient clinic settings, and for other physicians/health care workers to help with inpatient care.

Emerging therapies and impact on demand

Expert focus groups of neurosurgeons, complex spine surgeons and interventional neuroradiologists were asked about new and emerging procedures and technology anticipated to impact their respective specialties within the next 3, 6 and 9 years. The following procedures were identified:

- Endovascular treatment of cerebral aneurysms;
- Vertebroplasty for fractures of the spine related to osteoporosis;
- Decompression and stabilization of the spine in metastatic disease;
- Artificial discs for degenerative disease of the spine;
- Functional NS for Parkinson's disease;
- Surgical treatment of epilepsy;
- Intra-arterial thrombolysis for the treatment of acute stroke; and,
- Angioplasty and stenting of carotid arteries to prevent stroke.

All of these therapies and technologies should undergo systematic review and appropriate evaluation. Before widespread adoption the evidence base for their effectiveness should be proven. As noted, clinical trials are underway for some of these emerging areas.

Endovascular treatment of cerebral aneurysms

Aneurysms are outpouching of blood vessels that can rupture in the brain and result in a subarachnoid hemorrhage. Aneurysms can be treated by surgical clipping or by endovascular treatment, (insertion of coils into the lumen to prevent rupture). In Ontario, interventional neuroradiologists do almost all of endovascular treatment.

There is a role for open surgical clipping and endovascular management of aneurysms. Treatment recommendations differ for the ruptured and unruptured state. For ruptured aneurysms, treatment is directed at reducing rebleeding. The International Subarachnoid Aneurysm Trial (ISAT) trial reported improved outcome at one year for patients treated with coiling.[9] The long-term outcome of this treatment is not known and is under investigation. A second study, the International Study of Unruptured Intracranial Aneurysms (ISUIA) reported an increased risk of rupture of aneurysms with a diameter greater than 7 mm.[7] Although there have been no comparisons of the two types of treatment in unruptured aneurysms, endovascular treatment is a reasonable alternative.

While responses to the study's workforce survey indicated that the technology for coiling of aneurysms was available to all interventional neuroradiologists in Ontario (see Chapter 5 on technology assessment, Exhibit 5.3), a potential increase in this procedure was anticipated by both the NS and IN expert focus groups.[6,8] Because of the ISAT results, there is an increased role for the endovascular treatment of ruptured aneurysms. This urgent treatment is provided at the time of presentation. In addition, a number of factors led to increased demand for the endovascular treatment of unruptured aneurysms. The increased availability of improved brain imaging has led to the diagnosis of unruptured aneurysms in patients undergoing investigations for other reasons. Approximately one-half of the unruptured aneurysms requiring treatment are done by endovascular means.[6] The remaining more complex aneurysms continue to be treated by neurosurgeons.

Vertebroplasty

Vertebroplasty is a procedure to treat fractures of the spine resulting from osteoporosis. Osteoporosis, the weakening of bones, can result in fractures throughout the body. Individuals at increased risk of osteoporosis and fractures are postmenopausal women and the elderly. In Canada, it has been estimated that 16% of women over the age of 49 suffer from osteoporosis.[11] In the US, osteoporosis is believed to be responsible for 1.5 million fractures at a cost of $5–10 billion per year.[12]

Fractures of the spine are associated with severe pain that can impair level of functioning and quality of life. These fractures can result in deformity of the spine and lead to further injury. Vertebroplasty involves the injection of "bone cement" into the collapsed vertebrae to stabilize the fracture. Interventional radiologists in the US and Canada currently perform this procedure. Both the CS and IN expert focus groups anticipated an increase in the demand for this technology. Based on the study's workforce survey responses, this technology is available to 59% of neurosurgeons (Chapter 5, Exhibit 5.1) and 50% of CS surgeons (Chapter 5, Exhibit 5.2) in Ontario. However, the projected rising need is due to an expected prevalence of osteoporosis in the aging population and growing emphasis on women's health.[2,7]

There are other treatments for osteoporotic fractures and in many cases the symptoms spontaneously resolve in 3–6 weeks. Evidence to define the exact role of vertebroplasty needs to be determined.

Decompression and stabilization of the spine in metastatic disease

The spine is a common site of metastasis for cancer of many origins. Metastatic spread to this site can lead to spinal cord compression, neurological impairment, and paralysis of the limbs, painful spasms, and impairment of bowel and bladder function.

Until recently, the condition has been treated with radiation therapy. Surgical decompression and stabilization of the spine was reserved for a small proportion of patients. However, a study presented at the 2003 meeting of the American Society of Clinical Oncology reported additional benefits to patients that received surgical treatment with radiation.[13] Of 101 patients, those treated with surgery and radiation retained the ability to walk longer than those treated exclusively with radiotherapy. While this procedure does not require new technology, it has the potential to cause a rapid increase in demand for spine surgery for this type of patient. The rise in referrals is also anticipated to incur an increase in outpatient assessments and surgical treatment or operating room time.[7] Further research to confirm this initial study is needed.

Artificial discs for spine surgery

Degenerative disease of the spine can result in severe pain and impairment in level of function. Traditional therapy was fusion of the joint using bone grafted from another site (usually the hip), and, more recently, bone morphogenic proteins were used to eliminate hip pain. However, a significant limitation of fusion is reduced range of motion. Artificial joints, currently used in Ontario, vary in design and material and permit mobility at the joint and a greater range of movement.[14] The study's workforce survey responses indicate that this is available to 22% of NS surgeons and 27% of CS surgeons. The complex spine expert focus group anticipated that patient expectations would lead to an increase in demand for this procedure. Patients are requesting surgical treatment for pain instead of the prolonged conservative non-surgical approach.[7] The preferred surgical treatment is one that would increase mobility and promote activity. As with other new technologies and approaches, a systematic review of the evidence outlining the short and long-term benefits is needed.

Functional neurosurgery for Parkinson's disease

Parkinson's is a degenerative disease resulting from a deficiency of the brain neurotransmitter dopamine. This deficiency creates a disparity between circuits in the brain causing slowing of movement, rigidity, tremor and difficulty with balance.

A variety of medications are used to increase levels of dopamine in the brain. However, the effects of these medications are finite and the benefits are seen in the first five to seven years of use. In addition, patients may develop debilitating side effects to this treatment. In patients that no longer respond to these medications, surgical therapy has been shown to reduce impairment.

It is estimated that 100,000 Canadians are living with Parkinson's disease.[15] With advances in surgical therapy coupled with the finite benefits of medications, the NS expert focus group predicted an increase in demand for this procedure in the near future.[6] Because small discrete areas of the brain are targeted, the procedure does not require a specific technology. However, it is heavily dependent of the availability of highly sensitive intraoperative imaging and collaboration with other specialists for the lengthy pre-operative assessment and post-operative patient care.

Surgical treatment of epilepsy

Epilepsy is characterized by recurrent seizure activity that may be caused by any process that results in injury to the brain. It affects 0.5–1% of the world's population.[16] Medications are used to control seizure activity, but in 30–40% of patients this is inadequate.[17] Surgical treatment involves removal of the region of the brain that serves as the focus for seizure activity. This is recommended for adult and pediatric patients with uncontrolled seizures or refractory epilepsy. While the magnetoencephalogram (MEG) may be beneficial for this type of surgery, this was available to only 18% of surgeons. The use of MEG also requires highly sensitive intraoperative imaging and collaboration with other specialists for patient assessment and pre- and post-operative care.

Intra-arterial thrombolysis for acute stroke

Stroke, resulting from the disruption of blood supply to a region of the brain, is the third leading cause of death in Canada.[18] The most common type is the blockage of one of the arteries supplying the brain. In Canada, the incidence is 50,000 per year and the prevalence is 300,000.[19]

Of stroke survivors, 20% require placement in long-term care institutions and 15% require assistance with daily living.[18] The direct and indirect costs of stroke for one year are estimated to be $857 million[20] in Ontario, and $2.7 billion in Canada.[21]

Treatment using an intravenous injection of medication to dissolve blood clots blocking the arteries is available to patients that present within three hours of the onset of their symptoms.[22] However, injection of the medication directly into the blocked artery in the brain can be given to patients that present within six hours of symptom onset.[23] This is done in specialized centres by interventional neuroradiologists.

Required technology includes microcatheters to gain access to the artery in the brain and the clot dissolving medication (t-PA). While all interventional neuroradiologists reported access to microcatheters and t-PA, the expert focus group anticipated an increase in the demand for this treatment through organized stroke care in Ontario. Increased public awareness of the need to reach a hospital within the critical time window for this treatment, is also a contributing factor for increased demand.

Angioplasty and stenting of arteries of the brain

One quarter of strokes are caused by the formation of blood clots in narrowed vessels in the neck.[24] After a warning or minor stroke (Transient Ischemic Attack–TIA), patients with severe narrowing of neck vessels undergo carotid endarterectomy, a surgical procedure to prevent a second stroke. As an alternative to endarterectomy, a radiological procedure (angioplasty and stenting of the arteries) is being investigated in a number of centres and clinical trials comparing these procedures are underway.

In addition to the technology for angioplasty and stenting, cerebral protection devices have been developed to prevent blood clots from traveling to the brain during the procedure. While all of the interventional radiologists responding to study's workforce survey indicated access to angioplasty and stenting technology, 83% reported access to cerebral protection devices (Chapter 5, Exhibit 5.3). Although the clinical trials have not been completed, the IN expert focus group anticipated an increase in demand for this procedure as developments in technology have established this as an alternative for patients that cannot be treated by surgery.

Chapter 2—Neurosurgery

Introduction

Neurosurgery (NS) is the most well-defined of the neurosurgical areas studies in this report. With the largest number of providers, the most defined areas of clinical practice, and the easiest identification in established workforce and utilization databases, there is a greater degree of robustness in the findings for NS.

Core areas of activity

Based on input from the Provincial Neurosurgical Task Force and Expert Focus Group, core neurosurgical activity was divided into the following categories: cranial, spinal and "other" procedures (Exhibit 2.1). Although these represent the bulk of NS services, not all neurosurgeons provide these services. In addition, there are other services performed in smaller numbers and often only by a select number of neurosurgeons. This chapter considers cranial and "other" procedures, while issues related to the delivery of spinal procedures are captured in Chapter 3—Complex Spinal Surgery.

This chapter highlights the diversity of care provided by a relatively small number of providers, and discusses trends within the current workforce that have implications for the training of future neurosurgeons and related specialties.

Current Situation

Demand for neurosurgery services

There is currently no provincial waiting list or caseload registry for neurosurgical services. The report from the expert focus group and the results of the study's workforce survey indicate that demand for NS services generally does not exceed supply and there are no significant wait lists for surgical care.

Demand for NS is primarily met by the following means:

- Many cases, such as ruptured aneurysms and subdural bleeds, are treated on an emergency basis;
- Careful balancing and selection of surgical cases (e.g., priority treatment for symptomatic disease);
- Other surgeons providing services* that neurosurgeons consider core to their discipline;
- Neurosurgeons providing a large number of weekly clinical hours including on-call hours.

**An analysis of Ontario Health Insurance Plan (OHIP) billings for 2002 indicates that only 30% of carotid endarterectomies were performed by neurosurgeons. Similarly, although the focus group identified carpal tunnel releases as a procedure they should be very involved in providing, only 4% were done by neurosurgeons.)*

Supply of neurosurgery services

Ontario's NS services are available exclusively in larger urban settings and are frequently linked to academic health science centres. Several physician disciplines provide the NS services listed in Exhibit 2.1. For example, orthopaedic surgeons contribute to complex spinal procedures; interventional neuro-radiologists are becoming increasingly involved in certain cranial diseases; and vascular surgeons are performing carotid endarterectomies. However, essentially all the cranial services listed are performed by neurosurgeons.

The study's workforce survey results indicate that the neurosurgeon workforce is predominantly male and located in academic settings. Based on hospital information, Exhibit 2.2 outlines the number of physicians in each centre providing neurosurgical care. An adjustment in total numbers based on the volume of services provided by an individual physician relative to others in that centre is also provided (an explanation of the rules for adjustment is provided in the Data Analysis section of Appendix B).

The ICES Physician Workforce Database (IPWD) provides a historical perspective of neurosurgeons in the province.[25] Entrance into the workforce was largely through younger physicians (under age 40) and typically at a rate of one new physician per year (Exhibit 2.3). From 1993 to 2001, 23 new entrants were identified. During the same period, 24 physicians exited from the system, 16 of which were beyond age 55.

There has been a gradual trend towards an older workforce. In 1992, neurosurgeons under age 40 represented 26% of the workforce, compared to 48% for those aged 40–55 years. In 2001, the 20% of the workforce was under age 40, 58% was in the 40–55 age group, and the percentage of neurosurgeons older than 55 years of age decreased slightly from 25% to 23% (Exhibit 2.4).

The relation of neurosurgeon numbers, as measured through a full-time equivalency (FTE) measurement, to the general population has remained essentially unchanged. The overall FTE has risen steadily from 61 in 1992, to 70 in 2001, with a peak of 73 in 2000. However, the rate of FTE per 10,000 population has experienced only minute change with 0.057 in 1992, 0.059 in 2001, and a peak of 0.062 in 1999 and 2000 (Exhibit 2.5). These FTE numbers are different than the adjusted numbers presented in Exhibit 2.2. The IPWD uses different databases to identify the number of physicians in practice and bases the calculation of FTE on a formula developed by CIHI (See Appendix B for more information).

The FTE activity of neurosurgeons varies by age, and within a given age group, the workload has changed over time. Those aged 40–55 tended to work above the average workload while those less than 40 years old worked at about the average workload level. The most dramatic change was observed in the over 55-year age group. In 1992, this group worked at 67% of the workforce average but by 2000, was performing at almost the same level as those in the 40–44 age group (92% vs. 96%) (Exhibit 2.6).

Results from the workforce survey of neurosurgeons also suggest that there are differences in the activity pattern of physicians depending on age (Exhibit 2.7). Older physicians (over age 55) have the highest clinical activity. The youngest group of neurosurgeons has the highest average numbers of hours spent on teaching and research in a typical week. Physicians in the middle of their career were more likely than those in the other age groups to engage in administrative work and other activities such as continuing medical education (CME).

There were also differences in practice profiles among academic and community-based neurosurgeons (Exhibit 2.8). While community and academic neurosurgeons worked a similar number of clinical hours, the academic neurosurgeons had higher total weekly averages of work hours due to research and teaching obligations.

Neurosurgeons have a significant burden of on-call obligations. The 2003 annual Ontario Medical Association (OMA) health human resources mail survey of provincial physicians reported that neurosurgeons ranked seventh highest in terms of available on-call hours in a typical week. In addition to the high frequency of on-call, NS was second (1 hour less) to obstetrics and gynaecology, with regard to workload while on-call (i.e., actually called into hospital for clinical obligations).[26]

Community and academic surgeons provide a similar number of on-call days and procedures each month. However academic neurosurgeons see a greater number of patients while on-call. It was unclear from the study's workforce survey if the academic neurosurgeons numbers reflected the role of their in-hospital residents (Exhibit 2.9).

Neurosurgeons in academic centres benefit from the services of residents and fellowship level trainees. In the absence of trainees, community-based neurosurgeons (focus group and workforce survey respondents) reported relying more heavily on other physicians/health care workers and surgical assistants to support workload. The lack of trainees in community settings is important in the context of on-call duties. With appropriate supervision, trainees can provide a significant amount of assistance, particularly as a first level assessment of need for neurosurgical involvement when a referral is made.

In 2004, there were 16 entry-level training positions for NS across Canada (excluding francophone schools in Quebec). This is similar to other surgical sub-specialities such as plastic surgery (13), Urology (17) and Otolaryngology (18). Seven of the NS training positions are in Ontario (Exhibit 2.10).

Neurosurgery training programs are typically among the lengthiest of all surgical specialties. Typically lasting a minimum of six years, additional research (including degree programs such as masters and PhD) and fellowship training can extend the program for several more years.

One major impact on the supply of neurosurgeons in Ontario has been the emigration to other parts of the country and the United States (US). Data from the Canadian Post-Graduate Education Registry (CaPER) suggests that within two years, 40.7% of graduates from an Ontario program were located in the US. By five years post-graduation, the emigration rate rises to 60%. Information from the American Medical Association physician registry suggests a 50% exodus from Ontario to the US following training.

Regional distribution of neurosurgical services

The rate of neurosurgical services is distributed relatively equally across the province (Exhibit 2.11). The following Local Health Integration Networks (LHINs) had rates 10–25% lower than the provincial average: South East, Central West and Waterloo Wellington. Only LHIN Erie St. Clair had significantly higher rates at more than 30% the Ontario average. These variations adjust for variations in the age and sex of the population in the different LHINs.

The localization index refers to the percentage of cases in a given LHIN performed by locally available resources (Exhibit 2.12). Toronto Central, Southwest and Champlain LHINs provide care for at least 95% of their own cases. Mississauga Oakville, likely due to its proximity to Toronto Central, had the lowest localization at 64%. The remainder of the regions had localization percentages ranging from 72% to 83%.

An alternative view is to consider what percentage of a centre’s NS services is delivered to its local population compared to that migrating from other regions (Exhibit 2.13). Erie St. Clair, Northwest, Northeast, and Champlain provide services almost exclusively (>=95%) to their own populations. By contrast, only 23% of Toronto Central’s services are provided to the local population. Mississauga Oakville is the next lowest with 53% service provision to local population (23% of cases are from LHIN Central West).

Regions without NS services (LHINs: North Simcoe Muskoka, Central East, Waterloo Wellington, Central West, Central) typically seek care at the closest centres. For example 46% of cases from LHIN Waterloo Wellington are performed in LHIN Hamilton Niagara and 35% in LHIN South West. Of the cases from the LHIN Central, 95% are treated in LHIN Toronto Central.

The Future

Demand for neurosurgery services

The expert focus group predicted that there would be a moderate increase for most of the core procedures over time (Exhibit 2.14). The increases are driven by factors such as an aging population with rising cancer rates, and a growing use of technology that results in more incidental findings of “cold” aneurysms (i.e., aneurysms which have not bled) and other cranial anomalies.

In addition to changes in core activities, it is also anticipated that there will be a growing demand for new procedures. Several new areas of neurosurgical activity are being explored including chronic pain, spasticity, epilepsy and Parkinson’s disease. The last two, in particular, were felt to be potential growth areas over the next 3–9 years.
Changes in other areas of medicine may also affect the need for NS services. For example, the treatment of brain cancer (primary and metastatic) through advancement and integration of techniques such as

radiation and chemotherapy could lead to this chronic disease becoming amenable to more primary and repeat surgical interventions.

In addition to having a greater volume and variety of cases, the new procedural areas (such as epilepsy and Parkinson's surgery) are time intensive pre- and post-surgery as well as intra-operatively. The expert focus group did not anticipate shifts in technology that would significantly reduce the surgical time for existing or new procedures. However, it was felt that an older population with more co-morbid conditions could lead to increased operating and post-operative time.

Patient education and consumer empowerment have increased dramatically, and the office setting is another area in which rising demand on a neurosurgeon's time is anticipated. Furthermore, the complex nature of neurosurgical care takes time to explain in a manner that ensures patients understand the risks/benefits and make informed decisions.

Finally, as screenings become increasingly routine, demand for consult service grows with the accompanying number of incidental findings, such as the "overcalling" of normal pressure hydrocephalus and cranial cysts on CT scans. The expert focus group estimated that 35–40% of cranial referrals require surgery (compared with 5% for spine).[6] There are currently limited other professionals with the skills to be able to screen or respond to these referrals.

Supply of neurosurgeons

Sub-specialization

The study's workforce survey respondents were evenly split between those who have an area of specialization (defined as at least 75% of their time in one area) and those who have a broad-based practice. However, many respondents indicated a plan to specialize in the near future.

Both workforce survey respondents and expert focus group members indicated that the division between spinal and cranial procedures was growing. Furthermore, new areas such as epilepsy or interventional neuroradiology (IN) could become areas where neurosurgeons exclusively focus their practice.

This trend to sub-specialization is also occurring in other areas of medicine including general surgery, internal medicine and family medicine. However, further specialization of an already highly focused discipline with limited physician numbers has significant implications for health human resources. Sub-specialization will require more neurosurgeons to cover the basic services.

Another concern is whether there will be sufficient desire and skill comfort for highly sub-specialized neurosurgeons to share on-call duties where a broad range of clinical cases may present. Maintaining a sustainable call-roster is important given the already high volume and intensity of the on-call clinical demands. In addition, the sub-specialization of academic physicians could adversely impact the training of future community-based surgeons. It may be harder for academic centres to provide a training model (including appropriate mentorship) that reflects the skills needed.

Reduction in work hours

Numerous studies have shown that physicians in different specialties, particularly newly graduating physicians, wish to reduce their work hours. Approximately two-thirds of study's workforce survey respondents indicated a desire to spend more time with family and on outside work activities. The survey also indicated a desire to have more time to focus on non-clinical professional activities. Academic members of the expert focus group felt that research time was often compromised by high clinical demands. While academic respondents to the study's workforce survey indicated that approximately 12% of their time was spent on research, the expert focus group suggested a target of 30–50%. However, performing research requires appropriate training and support resources. It may also require a greater commitment of time than 30–50%. An alternative model may be to have a small number of physicians pursue research training and then devote the large majority of their time to research.

A related issue is the growing national and international attention to patient safety and medical error. Growing evidence from the medical and nursing disciplines suggests that prolonged work hours may be linked to poorer clinical outcomes and increased danger for the patient and the physicians. Largely driven by these issues, legislative initiatives in other countries are seeking to curb the number of hours physicians can work. Such restraints are already in place in industries such as long-distance trucking and aviation. Implemented in 1998, the European Working Time Directive mandates a maximum of 48 hours per week. Some courts interpret this as including physician on-call time.

In Ontario, recent contracts between hospitals and residents have changed on-call requirements from one in every three to one in every four days, with a greater effort to enforce the rules regarding cessation of work at noon on the post-call day. In addition to reducing the frequency of on-call requirements, recent contracts have also introduced other benefits such as maternity leave, and more protected educational time. Contracts for certain groups of physicians (e.g., northern family doctors participating in Northern Group Funded Plans) have included similar benefits, such as protected vacation time, educational leave and maternity leave.

Relocation

At the time of the study, several neurosurgeons planned to relocate outside of Ontario in the near future. Eight academic neurosurgeons and one community-based neurosurgeon indicated a planned change to relocate within the next two years. Over the course of the study period, at least two neurosurgeons closed their practices.

Increasing availability

As detailed earlier, approximately 40–50% of Ontario-trained neurosurgeons find employment in the US shortly after graduation. However, in the mid 1990s the American Board of Neurological Surgery (ABNS) decided not to recognize the training of foreign neurosurgeons that started residency after July 16, 1997, resulting in individuals being barred from working in the US. Given the length of neurosurgical training, the impact of this decision will only be realized in 2005.

The ABNS allows no exemptions to its legislation. Members of the Provincial Neurosurgical Task Force felt that a mechanism may be developed for particular individuals to be able to work in the US. It is also possible that the decision could be reversed or amended in the future. However, in the near future there is likely to be a significant increase in neurosurgeons seeking positions in Canada and specifically in Ontario, which has multiple centres. Recently, the *Canadian Medical Association Journal* reported that two newly graduated neurosurgeons had difficulty acquiring jobs in Ontario.

The shortage of opportunities for new entrants stands in contrast to the reported high workloads and desire for improved conditions by those already in the workforce. The issue seems to be a lack of hospital resources to support new entrants, particularly in terms of surgical time. Expert focus group participants indicated that they felt scheduled weekly surgical time was already very limited. The areas in which they felt that new neurosurgeons could assist with workload were in on-call responsibilities and clinical (as opposed to surgical) patient demands.

Role of other providers

The impact of orthopaedic surgeons and radiologists is discussed in Chapters 3 (Complex Spinal Surgery) and 4 (Interventional Neuroradiology). Plastic and orthopaedic surgeons are likely to remain involved in peripheral nerve cases, while vascular surgeons will continue to provide care for carotid endarterectomies. Most cranial procedures do not share significant overlap with other providers.

Residents and fellows are likely to continue to be important service providers in academic centres, however increasing educational demands and contract-imposed restrictions on working hours may reduce their role. Neurosurgeons in community settings are likely to continue to rely on inpatient physicians, critical care physicians and other medical specialists to help care for hospitalized patients.

It was felt that other health care providers, such as advanced trained nurses, physician assistants, clinical assistants and nurse practitioners, could also play an important role. These providers are often used for hospital-based care in the post-operative setting for other disciplines. However, the focus group felt that, unlike other conditions such as joint replacements or percutaneous cardiac interventions, neuroscience had a greater variety of clinical cases and an often greater illness acuity of patients. This made it more difficult to implement care protocols or develop training courses. Similar issues were raised about the role of other providers in the office setting.

Health Human Resources Forecasting Predictions

Sufficient information was available about neurosurgical services to develop a basic demand- based forecasting model (see Appendix B for more detail). This model incorporates the predictions regarding future supply and demand to estimate the number of neurosurgeons that will be needed in three to six years. Theoretically, the model can provide information about the number of physicians needed based on narrow age and gender stratification. However, given the small number of providers it was necessary to eliminate age-based stratification and collapse small age groupings into larger ones. For similar reasons, the model also does not specify whether the recommended numbers are for academic or community-based practice.

Assumption 1—Shifts in demand

Assuming an increase in demand of 3% in three years for most of the core areas (excluding pituitary tumours and carpal tunnel) and 10% for craniotomy for aneurysms, approximately another 0.43 physicians would be needed to work in a manner similar to current physicians. A conservative estimate of a 3% rise in non-surgical clinical cases would result in the need for approximately 1 additional neurosurgeon.

Assumption 2—Shifts in total supply

Assume that by the end of three years, neurosurgeons in the two younger age groups reduced their total weekly workload to 70 hours. This would represent an 18% decrease for the youngest age group and an 11% decrease for those between the ages of 41–54. If the oldest age group reduced their total weekly hours to 65 (11% decrease) during the same period, 4.79 additional neurosurgeons would be needed.

Assumption 3—Shift in practice focus

Assume that in addition to a reduction in total work hours, physicians aged 40 and under, and those aged 41–54, devote 35% of their week to research (currently 23% and 15%, respectively). Physicians 55 and older could commit 15% (currently 5%). If there were no other changes to the distribution of their time, there would be a decrease of 47%, 42% and 18% in clinical activity for the three age groups ranging from youngest to oldest. If only half of the current physicians adopted this research-intensive approach, it would require an additional 4.72 physicians to maintain clinical services at existing levels.

Although many physicians express an interest in spending a portion of their time involved in research, a preferred model may be to have a small number of physicians who are almost wholly (beyond 75%) devoted to research. This would allow necessary training in research methods and targeted allocation of limited supporting resources.

Assumption 4—Migration and sub-specialization

The study's workforce survey results indicated that the province is likely to lose an additional 2–3 neurosurgeons in the next two years to increasing sub-specialization, retirement, and change of practice location outside of Ontario.

Assumption 5—Other providers

The model estimates clinical activity to be 35% surgically-related. This is similar to the 40% suggested by the expert focus group. If other health care providers could provide 10% of the remaining care, this would be equivalent to approximately two neurosurgeons. Other providers may also be able to assist with some of the care related to surgical cases such as post-operative care in hospital and in the clinic.

In summary, the major driver of future need is related to changes in the supply of neurosurgeons. If the first four assumptions held true, the number of additional neurosurgeons needed within the next three years would be approximately 13. If other health care professionals can be incorporated to reduce the current total clinical workload by at least 10%, then an estimate of 10–11 neurosurgeons is appropriate.

Overall Health Human Resources Implications

Changes in training due to sub-specialization

- The number of overall post-graduate positions may need to be increased. Any increase would have financial implications as well as an increased burden on teachers. However, trainees are also able to provide important clinical service throughout their training
- Increased core rotations and fellowship opportunities could be developed in areas of potential specialization such as CS and IN.
- Lengthening the training stream has been documented to have a significant negative impact on physician supply. Every additional year of training is a year of career-time that cannot be recovered. As NS has one of the longest training programs, opportunities to shorten the timeframe should be explored.
- Counter to the sub-specialization trend is the need to train neurosurgeons for community-based practice. This may require training in a community setting, rotations with a broader clinical skill set, and a clear acknowledgment by tertiary teaching centres of the value of community practitioners that helps foster trainee interest. Other disciplines including psychiatry, general surgery and family medicine have already developed community-based teaching programs in Ontario.

Changing workforce demographics

- Over an almost 10-year period, the clinical time commitment of older physicians has steadily increased. Whether this pattern is due to physician choice or due to increasing demand in the system is unclear. The long-term sustainability of relying on the oldest segment of the workforce for significant workload is questionable.
- There is a small but growing number of female neurosurgeons. Other disciplines have demonstrated strong differences in workload and practice profile between the sexes, particularly during the child-bearing years. This pattern would need to be monitored in NS and incorporated into health human resources planning.
- These trends support the need for more neurosurgeons.

Reduced clinical and on-call hours

- A reduction in clinical hours is being driven by several factors: a desire for a better balance of personal and professional life; a focus on patient safety; and more opportunity for professional activities, such as research.
- Reduced clinical hours will have an impact on the supply of services including on-call services.
- On-call services may be further impacted by trends towards increasing sub-specialization. There may not be sufficient sub-specialized neurosurgeons to provide reasonable on-call coverage. Conversely, sub-specialized surgeons may not have the desire or skill set to cover a broad-based practice.
- These factors are likely to increase the need for more neurosurgeons.

Other practitioners

- The role for other supports such as inpatient physicians and other surgeons needs to be better defined and incorporated in health human resources models.
- Non-physician clinicians (such as physician assistants and nurse specialists) could assist with service deliveries in the office and surgical setting, and can be included as part of an integrated model of health human resources neurosurgical care delivery.

Window of opportunity

- Changes to American licensing policies has closed the border to Canadian trainees leading to a significant pool of local, young and highly trained neurosurgeons seeking employment opportunities, creating a unique opportunity to recruit physicians.
- Such recruitment needs to also address infrastructure support.
- Location of future neurosurgeons should consider academic and community needs, as well as regional problems with distribution.

Chapter 2—Neurosurgery

Exhibits

Exhibit 2.1 Core neurosurgery services

I. Cranial

- Craniotomy – tumours
- Craniotomy – trauma/haemorrhage
- Craniotomy – aneurysm
- Surgical management – trans-sphenoidal approach of pituitary tumour
- Ventriculostomy
- Ventricular-peritoneal shunts
- Drainage of subdural hematomas

II. Spinal

- Lumbar disectomy
- Anterior cervical surgery for degenerative disease (+/- instrumentation)
- Lumbar laminectomy for spinal stenosis (+/- fusion)
- Open reduction and external fixation of fracture (secondary to trauma)
- Posterior decompression for metastatic disease (+/- instrumentation)
- Anterior decompression for metastatic disease (+/- instrumentation)
- Deformity surgery

III. Other

- Carotid endarterectomy
- Carpal tunnel

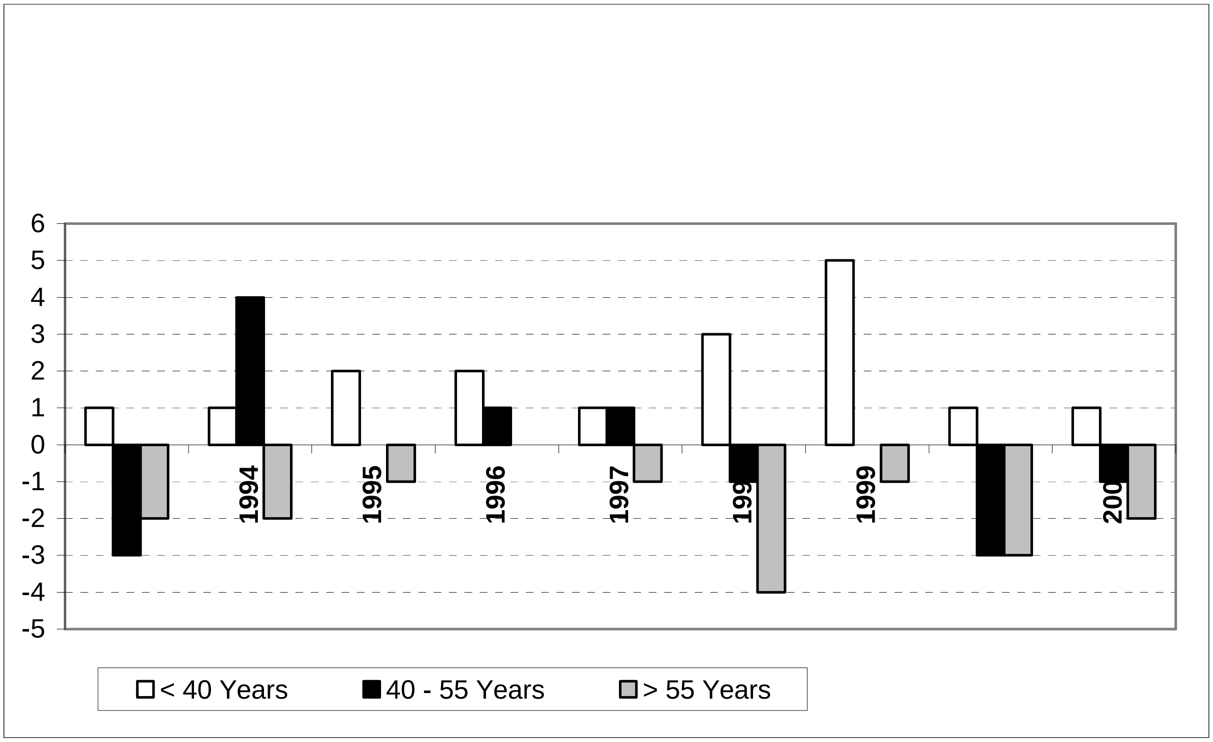
Data sources: Expert Focus Group and Provincial Neurosurgical Task Force

Exhibit 2.2 Number of physicians providing core neurosurgical services per site, in Ontario, 2001/02

Site	Number of physicians providing core neurosurgical services	Number of physicians adjusted for volume of services provided
Ottawa	9	4.50
Windsor	5	3.50
Hamilton	4	4.00
Mississauga	6	5.00
Sudbury	3	3.00
Thunder Bay	1	1.00
Kingston	4	3.00
London	7	5.25
Toronto (St. Michael's Hospital)	6	5.50
Toronto (Sunnybrook and Women's College Health Sciences Centre)	8	4.00
Toronto (University Health Network)	12	5.25
Total	65	44.00

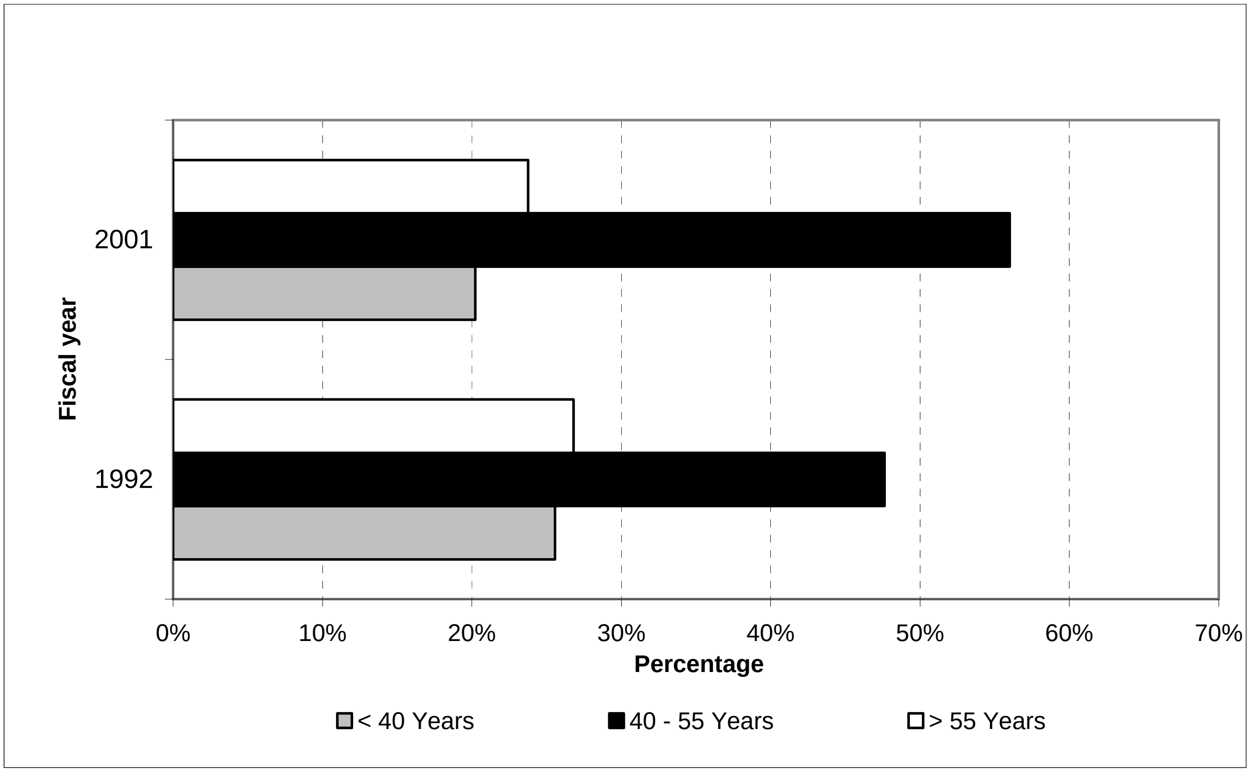
Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 2.3 Physician entries and exits by age group, in Ontario, 1993/94–2001/02



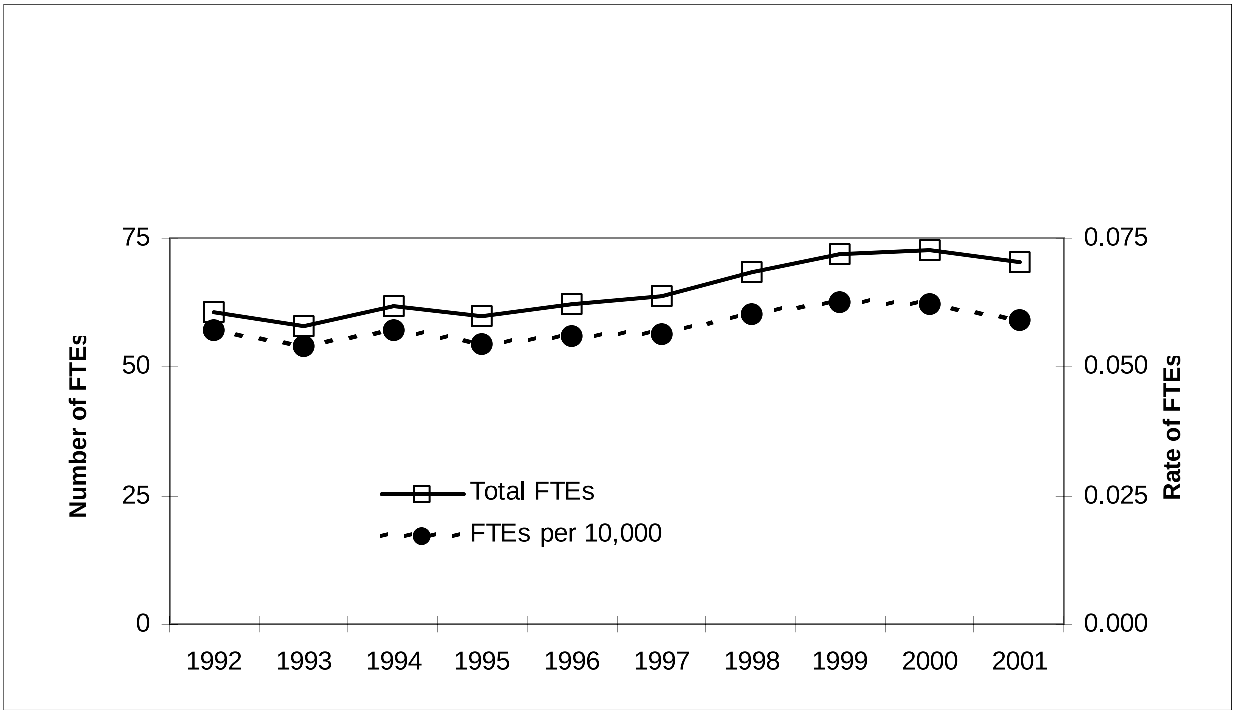
Data source: Institute for Clinical Evaluative Sciences—Physician Workforce Database

Exhibit 2.4 Age distribution of physician full-time equivalents, in Ontario, 1992/93 and 2001/02



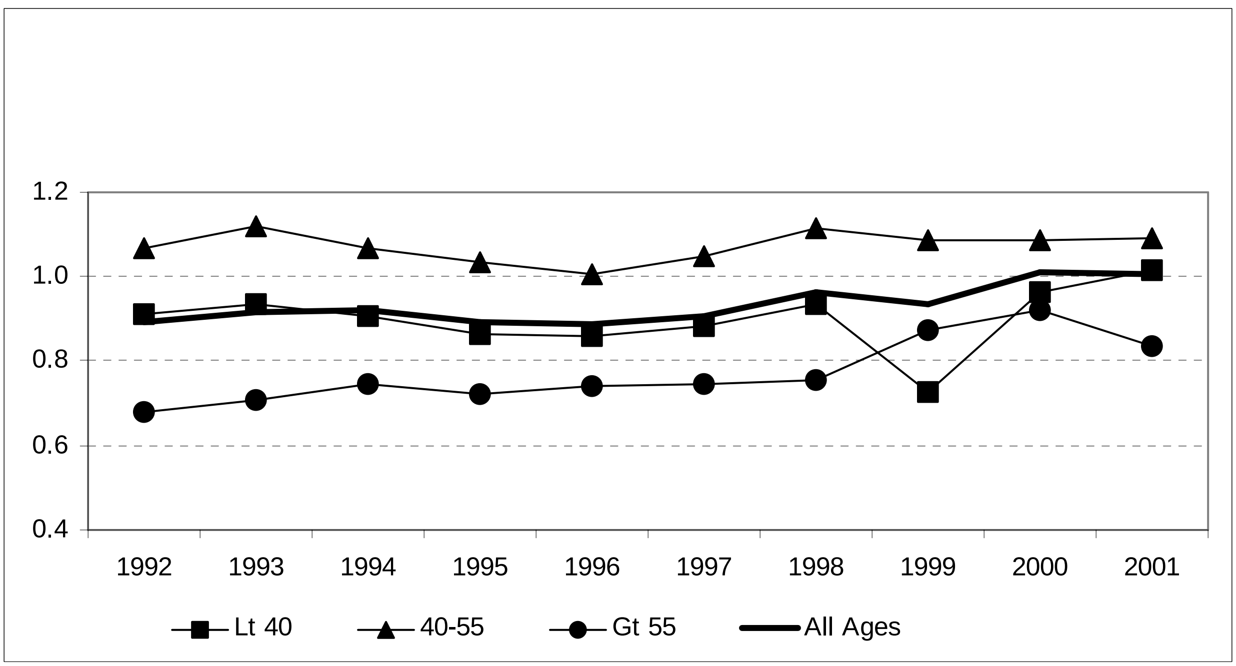
Data source: Institute for Clinical Evaluative Sciences—Physician Workforce Database

Exhibit 2.5 Total full-time equivalent physicians and rate per 10,000 population, in Ontario, 1992/93–2001/02



Data source: Institute for Clinical Evaluative Sciences—Physician Workforce Database

Exhibit 2.6 Full-time equivalent physician count ratio by age group, in Ontario, 1992/93–2001/02



Data source: Institute for Clinical Evaluative Sciences—Physician Workforce Database

Exhibit 2.7 Distribution of average weekly workload (in hours), by age group, in Ontario, 2004

Age Group	Clinical	Non-Clinical†	Teaching	Research	Other Activities‡	Total*	Weeks Worked Annually
<40**	49.62	5.69	5.38	15.25***	4.75	80.69	42.87
40–55	48.17	7.61	4.18	7.70	8.45	77.30	44.04
>55	51.46	6.14	4.07	5.64	5.54	72.86	44.67

*Numbers represent averages from all survey respondents, therefore, the total hours per week are not sum of all averages but the average of all sums.

**All are academic

***One respondent allocated almost all of his time to research and, therefore, affected the average for this group. Without this response, the average amount of research time was 9.57 hours.

† for example, administration

‡for example, continuing medical education

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 2.8 Distribution of average weekly workoad (in hours), by practice type, in Ontario, 2004

Practice Type	Clinical	Non-Clinical†	Teaching	Research	Other Activities‡	Total*
Community	50.64	5.00	1.45	1.82	6.64	65.55
Academic	49.05	7.55	5.14	9.38	6.84	78.98

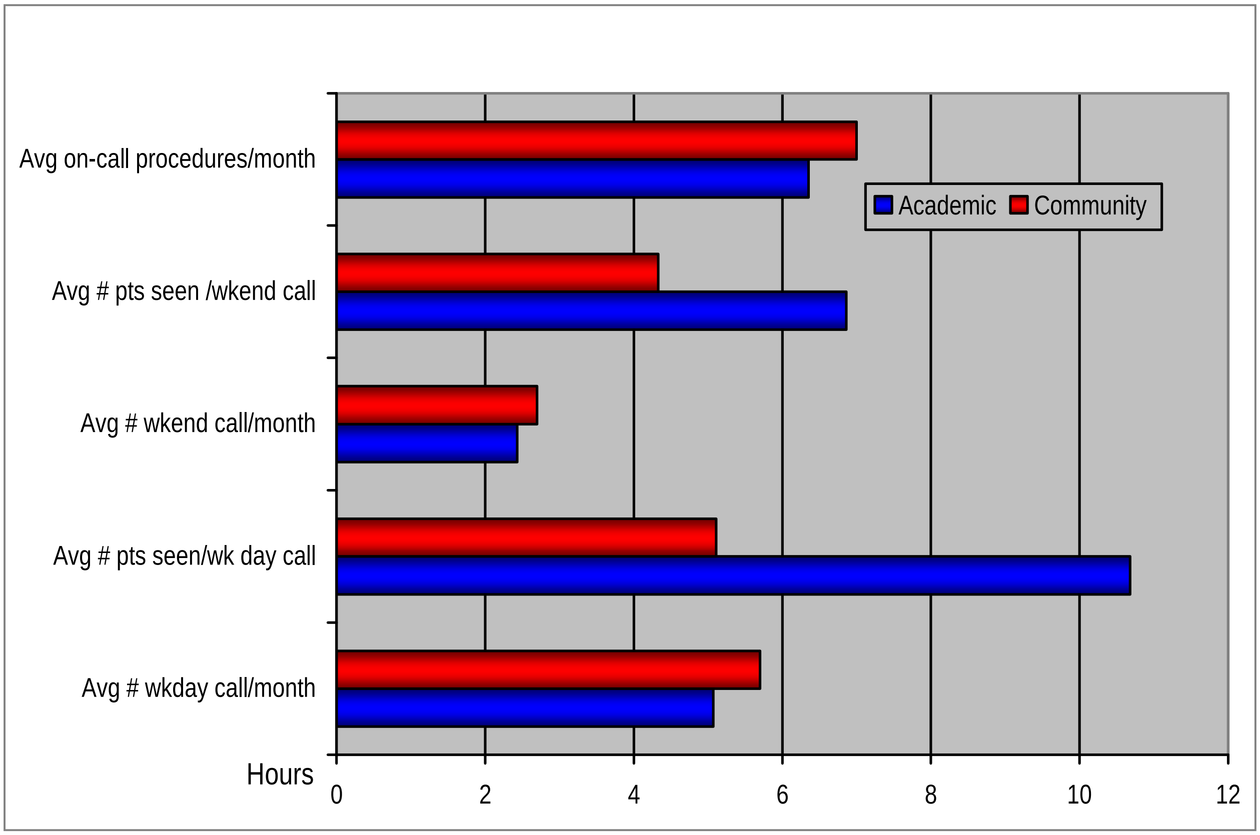
*Numbers represent averages from all respondents, therefore, the total hours per week are not sum of all averages but the average of all sums.

† for example, administration

‡for example, continuing medical education

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 2.9 Comparison of on-call demands between academic and community neurosurgeons, in Ontario, 2004



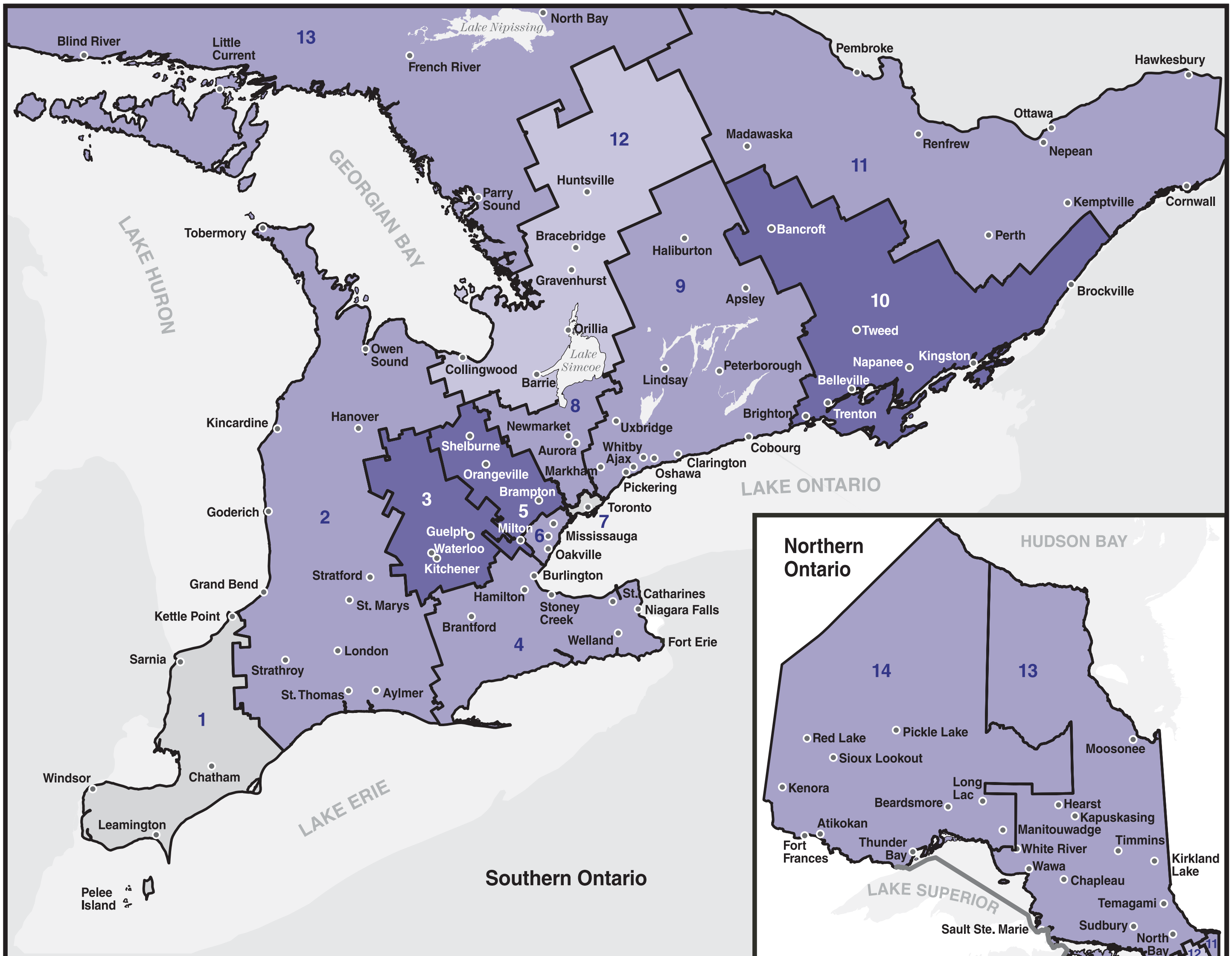
Data source: 2004 Neurosurgical Workforce Survey

Exhibit 2.10 Distribution of first year English-speaking training positions in neurosurgery, in Canada, 2004

School	Number of Neurosurgery Training Positions
Dalhousie University	1
McGill University	1
University of Ottawa	1
University of Toronto	4
The University of Western Ontario	2
University of Manitoba	1
University of Saskatchewan	1
University of Alberta	1
University of Calgary	2
University of British Columbia	2

Data source: Canadian Resident Matching Service

Exhibit 2.11 Rate of neurosurgical services utilization, by Local Health Integration Network, in Ontario, 2001/02



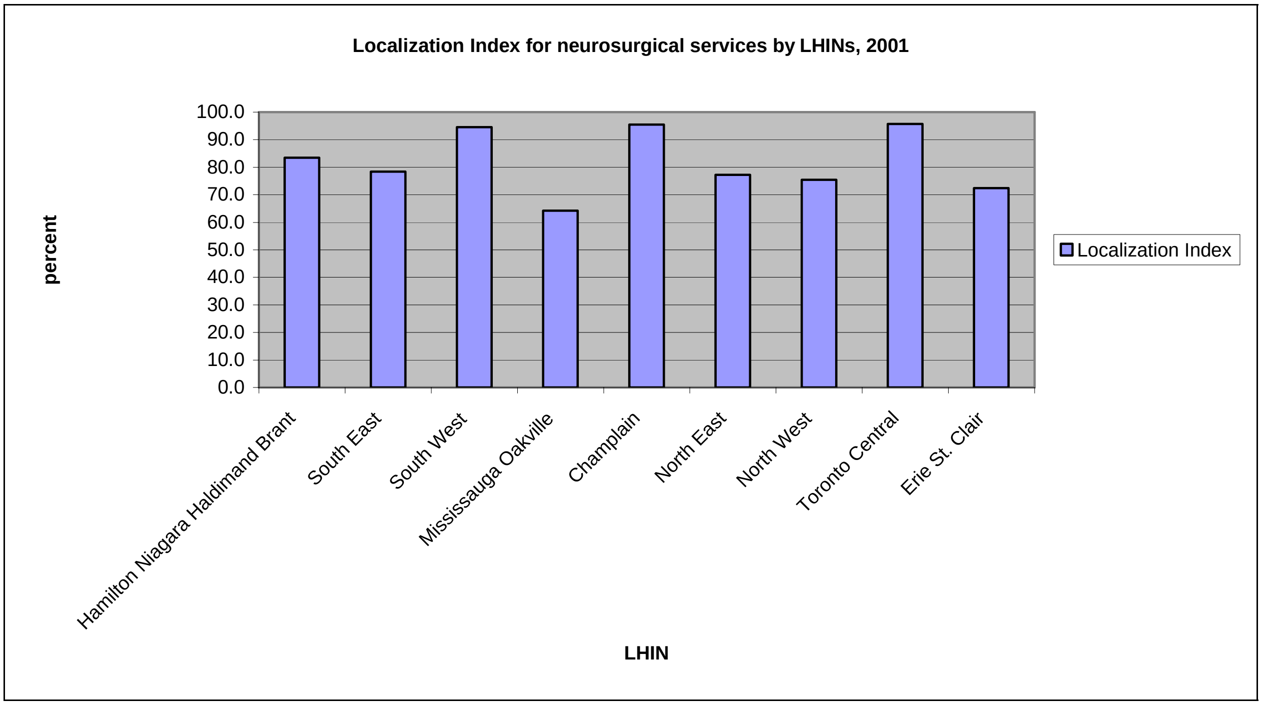
Local Health Integration Networks (LHINs)

1. Erie St. Clair
2. South West
3. Waterloo Wellington
4. Hamilton Niagara Haldimand Brant
5. Central West
6. Mississauga Oakville
7. Toronto Central
8. Central
9. Central East
10. South East
11. Champlain
12. North Simcoe Muskoka
13. North East
14. North West

Rate of neurosurgical services utilization, by Local Health Integration Network, in Ontario, 2001/02

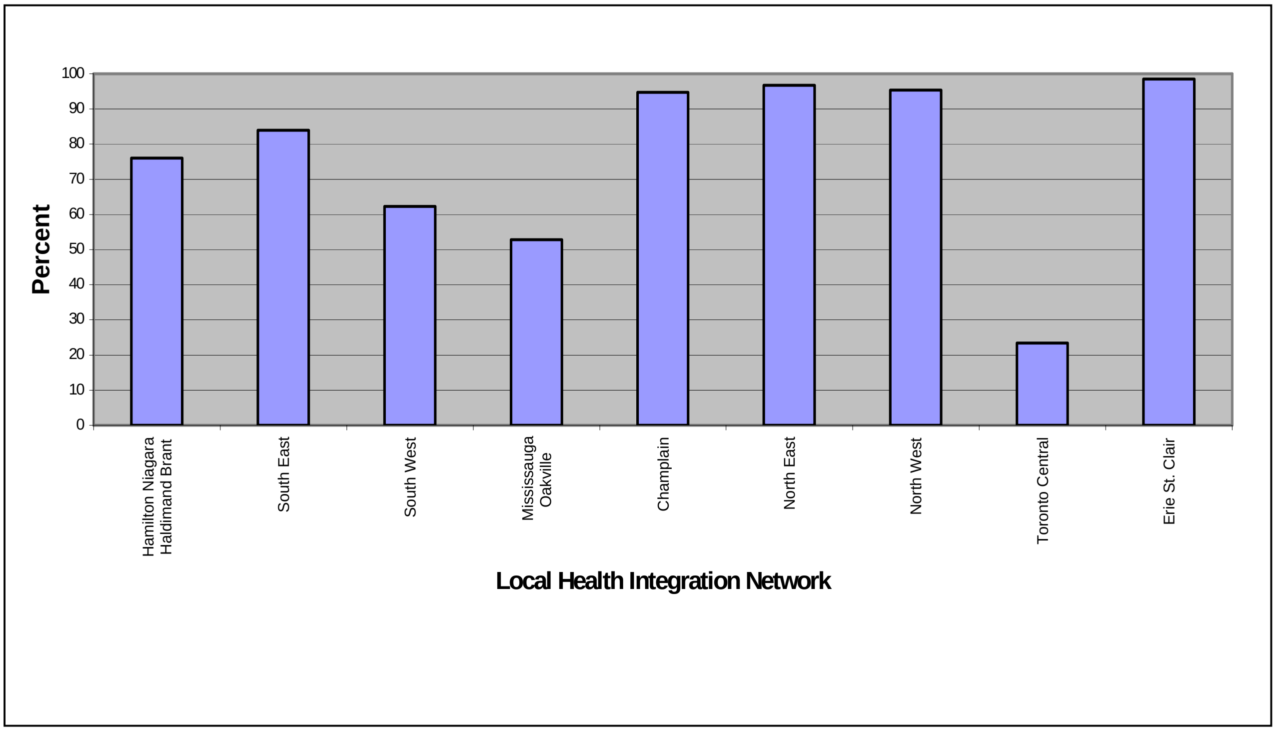
Comparative rate ratio	Number of LHINs in each category
0.75 to < 0.9	(3)
0.9 to < 1.1	(8)
1.1 to < 1.3	(2)
≥ 1.3	(1)

Data source: Canadian Institute for Health Information—Discharge Abstract Database



*Services not provided in LHINs: Waterloo Wellington, Central West, Central, Central East, and North Simcoe Muskoka
Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 2.13 Percentage of neurosurgery cases originating in the Local Health Integration Network in which they were treated, in Ontario, 2001/02



Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 2.14 Predicted change in demand for cranial neurosurgery services in Ontario

Disease/Procedure	Trend & Rationale	Estimated % Change within 3–9 Years
Craniotomy (tumour)	**Increase**: Aging population with more primary and secondary cancers. Wider cancer screening and incidental capture. Improved radiation and chemotherapy may expand survival of patients and role for surgery.	Approximately 3–5% increase every 3 years
Craniotomy (trauma/haemorrhage)	**Increase**: Benefit from car and road safety has reached plateau. Aging population with increases in bleeds from anti-coagulation use and amyloid angiopathy.	10–15% increase over 9 years
Craniotomy (aneurysm)	**Increase**: More routine imaging will lead to more incidental findings of "cold" aneurysms. Aging population may mildly increase ruptured aneurysms.	Cold: increase 10% in 3 years and 20% at 6–9 years
Pituitary tumour	**Stable**: Have seen recent decrease with medical management and radiation. Further decrease not foreseen.	No change
Ventriculoperitoneal shunt	**Increase**: More brain tumours and more normal pressure hydrocephalus with aging of population. More use of intrathecal chemotherapy for cancer.	10% by 9 years
Burr hole for subdural	**Increase**: Aging patients that can be unsteady on their feet, and taking anti-coagulants.	9% by 9 years
Carotid endarterectomy	**Increase**: Aging population leading to more strokes and desire for more aggressive prevention and management of stroke risk factors.	2–3% every 3 years
Carpal tunnel	**Stable**	No change
Data source: Expert Focus Group		

Chapter 3—Complex Spinal Surgery

Introduction

Complex spinal surgery (CS) is delivered by orthopaedic surgeons, neurosurgeons and, potentially, interventional radiologists. As with other areas of neuroscience, these specialized services are offered in only a few hospitals in Ontario, including four in the Greater Toronto Area.

Though CS is unmistakably an important service, a clear definition has not yet been achieved, and further, some of the procedures are relatively new. Consequently, it is difficult to identify levels of utilization and numbers of providers from administrative databases. However, information from expert focus group members and workforce survey respondents indicate that CS is an area of increasing interest for providers and is likely to see significant growth in demand.

This chapter provides an overview of this less understood component of neurosciences. Recommendations focus on the need to help meet growing demand, including the need to collect better data about the nature and volume of these services and evidence of patient benefit.

Core areas of activity

Based on the spinal procedures identified by the NS expert focus group, the CS group further refined the list of procedures (Exhibit 3.1). The procedures were organized into those delivered by both neurosurgeons and orthopaedic surgeons, versus procedures delivered exclusively by one of these groups. The procedures performed exclusively by neurosurgeons are low in number and, thus, were not included in the discussion about demand and supply.

Current Situation

Demand for complex spinal surgery

The expert focus group reported that urgent procedures related to trauma or metastatic cancer are addressed immediately, while operations such as lumbar discectomy, anterior cervical surgery for degenerative disease, and decompression for degenerative disease are significantly delayed. Current literature suggests that waits of greater than 3–6 months may affect the full recovery of patients with certain conditions, though expert focus group participants indicated that wait times can often be a year or more.

The greatest wait time typically occurs between the referral by a family physician or other professional and the first assessment by the complex spinal surgeon. Though most referrals are not inappropriate, relatively few cases turn out to be amenable to surgery. As one expert focus group member commented: “People wait 9 months for me to tell them in 10 minutes that there is nothing I can do for them”. Members of the CS expert focus group confirmed the opinion of the neurosurgical focus group that only about 5% of spinal consults lead to surgery, compared to 30–40% of cranial-related referrals.

Supply of complex spinal surgery

The current profile of CS surgeon supply in Ontario is as follows: (Exhibit 3.2)

- Approximately 50 full-time equivalent (FTE) CS surgeons;
- 30% are located in Toronto;
- 64% are in academic health science centres;
- The group is predominantly older and male.

Both expert focus group participants and workforce survey respondents emphasized being overwhelmed by the amount of work they are being asked to perform, particularly in the assessment of patients. High case volume, tied with insufficient operating room time, were identified as the number one barriers to seeing new non-urgent and urgent patients.

Community physicians consistently ranked high patient volumes ahead of other concerns, seeing significantly more new outpatients in an average week than their academic counterparts (Exhibit 3.3). They also identified few sources of support in the system, such as advanced care nurses and other physicians/health care workers providing inpatient care. These community-based surgeons often relied on surgical assistants (possibly family doctors or surgeons in other disciplines), while academic complex spinal surgeons noted some assistance from trainees (residents and fellows). However, compared to academic neurosurgeons, academic complex spinal surgeons noted less help from trainees. This may reflect the relatively smaller number of trainees/fellows in complex spinal surgery, or high case volume.

Community spinal surgeons provided more hours of clinical services per week. However, due to research and teaching activity, academic surgeons provided more total hours per week (Exhibit 3.4). Younger surgeons had the highest weekly workload and spent the most time teaching (Exhibit 3.5). The oldest group of surgeons spent the most time involved in research.

Regional distribution of complex spinal surgery

Rates of utilization varied significantly across Ontario's Local Health Integration Networks (LHINs). Three adjacent LHINs north of Toronto had rates at least 25% lower than the provincial average while LHINs North West, South East, Champlain and Erie St. Clair had rates of utilization more than 30% above the provincial average (Exhibit 3.6). These rates were adjusted for age and sex variations among the LHINs.

The localization index refers to the percentage of cases in a region serviced by local resources. The LHINs of South East, South West, Champlain and Toronto Central all rated 90% or greater while the LHINs of Hamilton Niagara Haldimand Brant, Mississauga Oakville and North East came in at about 68% (Exhibit 3.7).

Another perspective is to consider what percentage of the cases performed in a centre are from the local area. Only 20% of the cases in Toronto Central and 40% of those in Mississauga Oakville originated in those areas (Exhibit 3.8). This is in contrast to most other centres, which had rates above 90%.

The Future

Demand for complex spinal surgery

The expert focus group predicted significant growth for several of the core procedures in the next three to ten years (Exhibit 3.9). Future demand for services is largely related to age-related increases in degenerative disc disease (DDD). In addition, preliminary reports of increased benefit associated with a combination of surgery and radiation for patients with cancer of the spine is anticipated to result in increased demand for CS.[13] Increasing life expectancy is leading to higher volumes of age-related problems. At the same time, the current population also has greater expectations for general health and well-being as they age. As one survey respondent stated: "They expect to be able to retire at 70 and then golf for ten more years". More evidence about the clinical benefit and cost-effectiveness of CS should be gathered and incorporated into health human resources planning.

The complex spine focus group independently confirmed the views of the interventional neuroradiology (IN) focus group that there could be strong growth in demand for alternative methods, such as kyphoplasty, to treat degenerative disc disease, but it was unlikely to impact on the demand for traditional surgical management. The patients who could benefit from kyphoplasty are different in terms of the type of problems they have and how well they could tolerate traditional surgery. Minimally invasive surgical procedures are likely to be developed but these were not anticipated to change demand and, further, would lead to an increase in the time needed to perform procedures.

Supply of complex spinal surgery

Typically 2–3 years in duration, the two training streams for CS are through orthopaedics and NS, respectively. These fellowship training positions are usually funded through a combination of research grants, industry supports and clinical service funding through staff surgeons.

The need for more providers today and the future is apparent. However, the source of these providers (NS versus orthopaedic) is uncertain. There is reason to predict that neurosurgeons may become a more dominant provider of CS. With relatively stable demand predicted for many core neurosurgical procedures, and the anticipated siphoning of procedures into interventional techniques carried out by radiologists, neurosurgeons will have the capacity to expand further into the complex spine area. By contrast, the demand for orthopaedic surgeons to provide joint replacements and other procedures will grow substantially and may draw them away from CS.

Furthermore, spinal procedures are already well identified within the neurosurgical training stream and a component of most neurosurgeons' practice. In comparison, most orthopaedic surgeons will not do any spinal procedures. Despite these factors, there are more orthopaedic surgeons being trained than neurosurgeons. In 2005, there are 41 first year practice locations for orthopaedics compared to 16 for NS in Canada.

Some of the increased supply may also come from those already in the workforce. On the workforce survey, several neurosurgeons indicated an intention to increase focus on spine in the coming two years.

Role of other providers

In terms of procedures, there may be a role for IN in the management of some degenerative disc conditions (e.g., kyphoplasty). While this issue is further explored in Chapter 4 (Interventional Neuroradiology), it was the opinion of the complex spine expert focus group that the patient populations and indications were different for interventional therapy compared with surgical.

A significant role for non-physician providers was identified. The Provincial Neurosurgical Task Force reported on a current initiative in Alberta that uses physiotherapists and chiropractors to help screen referrals at first consult. Family physicians specializing in sports medicine are increasingly common and could serve as another source of support, as could physician assistants and nurse practitioners. The training of a nurse to perform the initial management of a referral for back pain could realistically be accomplished within a few months. Furthermore, advanced practice nurses or inpatient physicians could assist with post-operative care.

Overall Health Human Resources Implications

The trends outlined previously may have significant implications for CS health human resources. The shortfall in current supply will only worsen in the next few years as demand escalates.

Aging workforce

As with neurosurgeons and interventional neuroradiologists, complex spinal surgeons represent an aging workforce with a long training route before entry of new graduates into practice.

Significant workload pressures

Workforce survey respondents and expert focus group members reported that current levels of demand already appear to be exceeding the supply, particularly referrals for initial assessment and some emergency work such as trauma. The current level of frustration and high workload stood out compared to the other areas of study and speaks to the potential lack of short-term sustainability of the workforce.

Growing wait lists

Much of the wait time is due to delays between referral from a family physician or other professional and the first assessment. Given the predicted increase in demand, this trend will only worsen without intervention.

Change in scope of practice of other professionals

There is a potential role for other health professionals to help with office-based practice and in-hospital care of surgical patients.

Limited supply

Training positions are limited and do not receive consistent government funding. Spinal surgeons are also typically drawn from an already small pool of neurosurgeons. A greater number of fellowship positions with stable funding could help attract more individuals into the field. Enhancing the profile of CS within the orthopaedic residency program may help attract more individuals from this specialty.

Poorly recognized specialty

Better definition and recognition of CS may help lead to needed data collection about providers and the services they provide. Current data sources are inadequate for planning.

Chapter 3—Complex Spinal Surgery

Exhibits

Exhibit 3.1 Core complex spinal services

I. Neurosurgeons & Orthopaedic Surgeons

- Lumbar discectomy
- Anterior cervical surgery for degenerative disease (+/- instrumentation)
- Lumbar laminectomy for spinal stenosis (+/- fusion)
- Open reduction and external fixation of fracture (secondary to trauma)
- Posterior decompression for metastatic disease (+/- instrumentation)
- Anterior decompression for metastatic disease (+/- instrumentation)

II. Orthopaedic Surgeons

- Deformity surgery

III. Neurosurgeons

- Intradural tumours
- Tethered cord
- Syringomyelia

Data sources: Expert Focus Group and Provincial Neurosurgical Task Force

Exhibit 3.2 Number of physicians providing core complex spinal services per site, in Ontario, 2001/02

Site	Number of physicians providing core complex spinal services	Number of physicians adjusted for volume of services provided
Ottawa (General and Civic hospitals)	10	5.00
Windsor (Hotel-Dieu Grace and Windsor Regional hospitals)	6	4.00
Hamilton	8	4.50
Mississauga	8	6.25
Sudbury	4	3.00
Thunder Bay	5	3.50
Kingston (Hotel-Dieu and Kingston General sites)	10	5.00
London	12	4.25
Toronto (St. Michael's Hospital)	11	5.00
Toronto (Sunnybrook and Women's College Health Sciences Centre)	16	5.25
Toronto (Toronto East General Hospital)	3	1.75
Toronto (University Health Network)	16	3.75

Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 3.3 Patient volumes by physician group, in Ontario, 2004

Physician Group	Average Number of New Outpatient Consultations per Week	Average Number of New Inpatient and Emergency Room Referrals	Average Number of Surgical or Other Procedures per Week
Academic neurosurgeon	15	7.63	4.83
Academic complex spine surgeon	22	10.00	4.20
Community neurosurgeon	24	9.33	5.89
Community complex spine surgeon	31	7.90	5.27

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 3.4 Distribution of average weekly workload (in hours) by age group, in Ontario, 2004

Age Group	Clinical	Non-Clinical†	Teaching	Research	Other Activities‡	Weekly Average	Clinical Weeks per Year
<40	41.73	3.95	7.90	8.10	6.18	66.41	46.00
41–55	44.58	6.08	2.75	3.45	4.15	61.00	45.35
>55	43.13	4.50	1.50	11.25	3.50	63.88	45.00

† for example, administration

‡for example, continuing medical education

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 3.5 Distribution of average weekly workload (in hours) by practice type, in Ontario, 2004

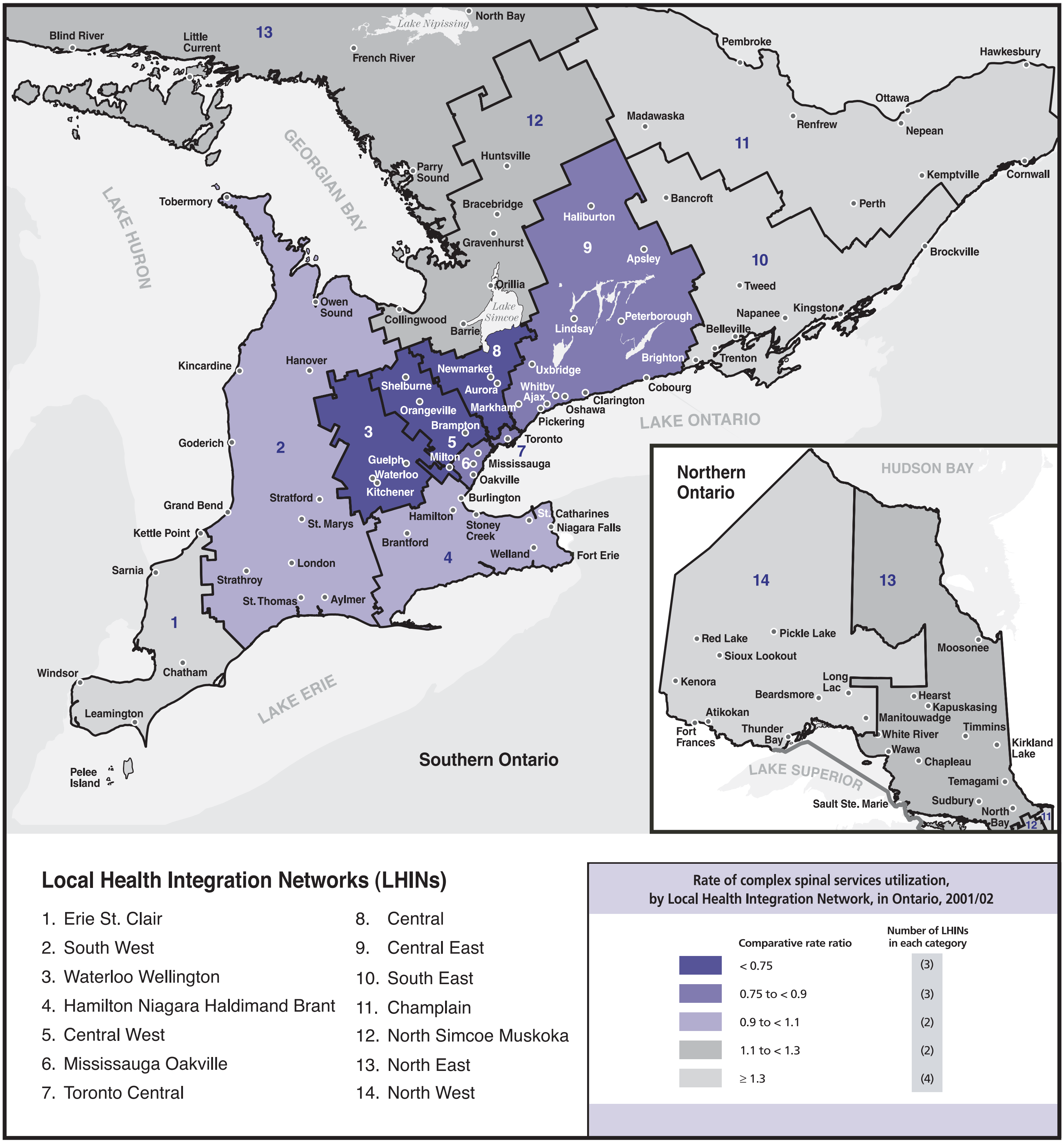
Practice Type	Clinical	Non-Clinical†	Teaching	Research	Other Activities‡	Weekly Average
Community	46.55	4.14	1.00	0.27	2.82	54.77
Academic	42.12	5.73	5.61	8.35	5.58	66.81

† for example, administration

‡for example, continuing medical education

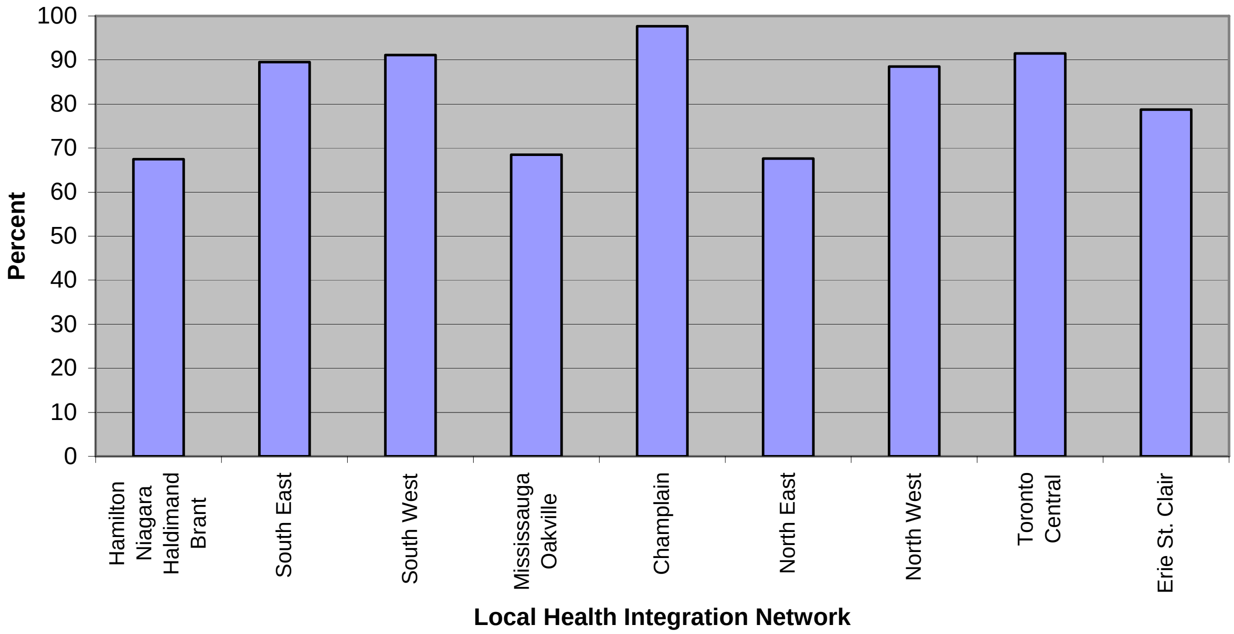
Data source: 2004 Neurosurgical Workforce Survey

Exhibit 3.6 Rate of complex spinal services utilization by Local Health Integration Network, in Ontario, 2001/02



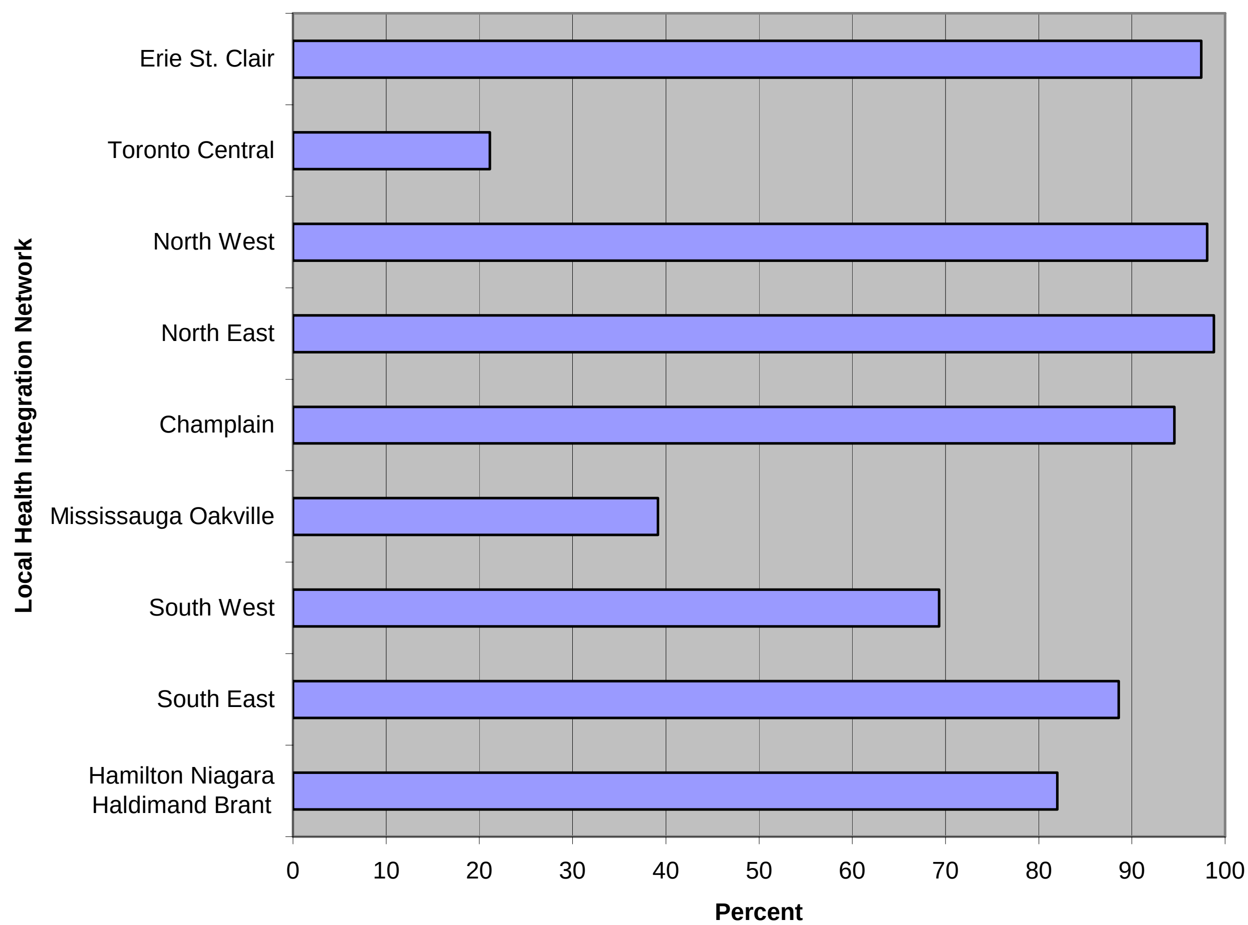
Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 3.7 Localization index for complex spinal services, by Local Health Integration Network, in Ontario, 2001/02



*Services not provided in LHINs: Waterloo Wellington, Central West, Central, Central East, North Simcoe Muskoka.
Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 3.8 Percentage of complex spinal cases originating in the Local Health Integration Network in which they were treated, in Ontario, 2001/02



Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 3.9 Predicted change in demand for core complex spinal services

Disease/Procedure	Trend & Rationale	Estimated % Change within 3–9 Years
Lumbar discectomy	**Increase**: The aging of the population along with expectations about ability to remain active during the senior years.	1–2% increase in 3 years
Anterior cervical surgery for degenerative disc disease (+/- instrumentation)	**Increase**: Similar rational as above. Role for interventional treatment or artificial discs unclear. New treatments may be for a different population of patients and actually increase demand. Furthermore, artificial discs may increase degeneration of adjacent levels thereby ultimately increasing demand.	No change
Open reduction and internal fixation of fracture secondary to trauma	**Stable**: Increase due to reduced role of Halo has likely already been seen.	No change
Decompression for metastatic disease (+/-) instrumentation	**Increase**: Recent abstract presentation suggests greater role for surgery. Aging of population with increase cancer rates suggests a resulting growth in demand.	5–10% increase in 6 years; 12–15% increase in 9 years
Decompression for degenerative disease (multilevel, single level)	**Increase**: As above, an aging population with increased expectation to remain active.	1–2% increase in 3 years
Deformity surgery	**Stable**: Current approach is to employ less aggressive management initially, and wait for degenerative changes to develop. This is also reflected by the anticipated increase in the other surgeries for degenerative disease.	1% increase in 3 years

Data source: Expert Focus Group

Chapter 4. Interventional Neuroradiology

Introduction

Interventional neuroradiology (IN) is an emerging area of neurosurgical sciences sub-specialization in Ontario. This field overlaps with the neurosurgery (NS) and complex spinal surgery (CS) areas. Though it currently represents a relatively small area of activity, IN has the potential for significant growth, which will have broad resource implications including health human resources for NS, CS and IN. Given the early stage of IN, there is an opportunity to establish systems to follow the development of the field and ensure that it evolves as a well supported and complementary component to the neurosurgical sciences.

Owing to the small number of physicians and low volume of procedures, the data presented here including that of regional variation, is not as robust as the analysis performed for NS and CS.

Core areas of activities

Interventional neuroradiology procedures can be categorized as cranial (including carotid vessels) or spinal (Exhibit 4.1). Cranial procedures can be either diagnostic or therapeutic, though the latter are performed in relatively small volumes as an alternative approach to surgical procedures. The most common IN procedure is the diagnostic cranial angiography. As non-invasive modalities have become more sophisticated and available, this procedure has seen a steady drop in frequency.

Cranial IN procedures (particularly the therapeutic type) are complex, often lasting several hours, and typically involve a high risk of morbidity and mortality, with many requiring significant inpatient after care. Spinal IN procedures are mostly performed on an outpatient basis with limited follow-up required.

Current Situation

Demand for interventional neuroradiology

For most services, needs are appropriately met, though for certain services there are access barriers unrelated to health human resources issues. Large regions of the province do not have ready access to IN services, significantly affecting acute services such as intra-arterial thrombolysis for stroke. This procedure has only a narrow window of time (3–6 hours) for the patient to present to the emergency room, be accurately diagnosed, and have treatment initiated. However, diagnosis and treatment require specialized technology and physician skills not available in most hospitals.

The treatment of acute aneurysms by IN is also underutilized. In this case, the issue of physician availability, particularly after hours, is the major barrier to access. For non-ruptured aneurysms, needs are better met but that wait times should be watched.

For some of the elective spinal procedures, demand may be low because there is limited public awareness (or even physician knowledge) of the role of IN for disc disease despite the growing prevalence of osteoporosis and degenerative disc disease. Members of the Provincial Neurosurgical Task Force reported that hospitals in other provinces, for example, Foothills Hospital in Alberta, utilize a greater number of these spinal interventions for treatment of pain.

Finally, IN for carotid angioplasty and stenting is currently undersupplied, particularly within the period recommended by guidelines based on small randomized control trials (RCT) in patient subgroups, such as those at high risk for surgical complications. A larger trial to compare angioplasty and stenting versus surgical endarterectomy is currently enrolling patients. This problem likely relates to lack of resources other than physician availability, including barriers to access of diagnostic imaging equipment and appropriate beds.

Supply of interventional neuroradiology

Supply of IN services is located exclusively in large urban settings and primarily in academic health science centres. This is due, in part, to the high degree of sub-specialization of the physicians, in addition to IN being performed in separate procedure suites with specifically trained interventional staff and specialized equipment.

There are a small number of IN physicians in Ontario. As reported by expert focus groups and results from the study's workforce survey, there are approximately 18 physicians, predominantly male with an age range of 31 to 64 years, and an average age of 48 (Exhibit 4.2). With the exception of one neurosurgeon, all IN physicians have a radiology background. Based on an analysis of service activities at hospitals, the number of IN providers appears to be higher than that reported by the expert focus group (Exhibit 4.3). The limitations of determining supply using service activity patterns are noted in Appendix B.

To a lesser degree than NS and CS, there are some overlaps in professional practice with other physicians. A small number of invasive radiologists (but not neuroradiologists) are involved in certain spinal procedures or less complex procedures like the management of epistaxis (acute hemorrhage from the nostril, nasal cavity, or nasopharynx). There are also some cardiologists involved in carotid angioplasty and stenting.

This profile is reported to be different from other countries, or even other provinces, where there is a wide array of physicians involved in different components of IN care. Cardiologists and vascular surgeons are often involved with carotid angioplasty and diagnostic studies. Similarly, there are more neurosurgeons involved with different procedures. Furthermore, there is a small, but growing, number of neurologists performing cranial-related IN procedures, particularly intra-arterial thrombolysis. Some spinal procedures are being performed by a variety of practitioners including interventional radiologists without specific neuroradiology training, orthopaedic surgeons, and anaesthetists.

While some of the procedures are done on an outpatient basis, many are complex, high-risk undertakings involving very sick patients that typically require intensive or step-down level care post-procedure. As with other advanced surgical procedures, such as cardiac bypass surgery or interventional cardiology, specially trained nurses are required to assist with the procedure and for after care.

Most IN physicians are radiologists who are also heavily engaged in other radiological activities outside of their interventional roles. It is estimated that only one-third of their time is spent on IN services.

One of the main issues facing IN physicians is the pressure of high on-call demand. Owing to their limited number, IN providers are usually on-call as frequently as every other night, or for long periods, even a week at a time. They are typically first on-call (no residents) for interventional procedures and advanced imaging techniques (not plain films or CT). While the on-call period generally produces relatively few cases (typically 3–5), the total number of on-call hours, length of procedures, and complexity of services, result in heavy workload demands. Furthermore, workforce survey respondents indicated that on-call hours and weekly work hours have increased in the last two years. In addition to on-call requirements, IN physicians, like their NS colleagues, carry other clinical and academic responsibilities (Exhibit 4.4).

There are many similarities between the neurosurgeons and interventional neuroradiologists. Both include a strong focus on teaching and research. Approximately 65% of IN workforce survey respondents indicated research and teaching as part of the reason for selecting a career in IN. However, a sub-analysis of the weekly number of hours spent on research indicates that the majority of individuals perform five or fewer hours of research per week and just a few individuals heavily invested in research. Expert focus group participants suggested 30–50% of their time should be allocated to research.

Currently, Ontario IN radiologists are trained through a 2–3 year fellowship that follows the normal 5-year Royal College of Physicians and Surgeons of Canada (RCPSC) radiology residency. International guidelines exist for outlining the requirements of fellowship. However, since the field has evolved quickly and relatively recently, many practicing radiologists have acquired the skills over time.

Although there are only a handful of IN physicians in Ontario, the main issue of supply stems from the insufficient number of other health care workers and the availability of technology and resources. The top issues include:

- Access to anaesthesia;
- Access to needed technology, e.g., diagnostic tools, medical devices, surgical equipment;
- Insufficient intensive care beds and/or critical care nurses;
- Lack of dedicated budgets with clear plans for consistent provision of services; and,
- Lack of timely access to existing resources.

Supply of services can also be affected by physician preference. In particular, IN providers reported that current remuneration for some spinal procedures is poor and that limits are placed on who can refer and how many cases will be done.

Regional distribution of interventional neuroradiology

There are marked regional variations in utilization of IN (Exhibit 4.5). Seven LHINs fall at least 25% below the provincial average, and four at least 30% above the provincial average. These rates are adjusted for age and sex variations among the LHINs.

The localization index (LI) refers to the percentage of cases in a given LHIN that are provided by locally available resources. The overall average LI for IN is slightly lower (80%) than for NS or CS (82%). The South West, South East, Champlain and Toronto Central LHINs were each over 90%. The lowest LI rates were in Hamilton Niagara Haldimand Brant LHIN (46%) and Erie St. Clair (56%) (Exhibit 4.6).

Another perspective is to analyze how many cases performed at a given centre are from its corresponding LHIN (Exhibit 4.7). Of the procedures done in LHIN North West, 100% originate from that region, and most other centres draw largely from their own area and from those immediately adjacent. Only 19% of procedures done in Toronto Central are from this LHIN. The majority of cases are from LHIN Central East (26%).

The Future

Demand for interventional neuroradiology

Many of the disease states treated by IN are fairly stable and have well-recognized incidence and prevalence patterns. These include strokes, tumours, epistaxis and aneurysms. With the exception of a slow increase (estimated at 2–3% per year) due to an aging population, there are not expected to be major shifts in the presentation of these diseases.

Demand for therapeutic cranial IN will be largely driven, at least initially, by the results of clinical trials. Several of these studies are underway and will serve to determine the role (safety and efficacy) of IN compared to traditional surgical and medical approaches. Diseases for which IN is being studied include carotid artery atherosclerosis, aneurysms (acute and non-acute) and acute thrombotic stroke, with results to date being positive. If additional research continues to be supportive there will be a significant increase in the role for IN.

For example, as noted in NS, carotid endarterectomy is a relatively common procedure. In recent years, IN procedures doubled, and with positive trial results, will likely double again within six years. Similarly, the management of aneurysms is a significant activity of neurosurgeons and acute strokes are common in the elderly population. It is estimated that IN will manage 50% of all ruptured aneurysms within three years, and 70% within six years. Intra-arterial thrombolysis for acute stroke could double or triple within three years.

Other therapeutic cranial procedures are unlikely to increase substantially—likely because technology has been available for some time without significant increasing demand (e.g., treatment of epistaxis), or the incidence of the disease is relatively low (e.g., skull-based tumours).

It is not anticipated that technological change will radically alter the overall demand for IN services. The technology is already available, however, more evidence through studies is required to prove clinical efficacy. Issues of public and physician awareness, as well as timely access to the services, are also likely to be greater determinants of demand than are changes in technology. The role for diagnostic cranial IN is likely to continue to decrease significantly with the development of non-invasive imaging modalities.

A significant group of patients could potentially benefit from therapeutic spinal interventions. Many disease states that benefit from spinal IN will increase with the aging of the population. There is also a growing medical and general population awareness of osteoporosis and osteoarthritis, coupled with a desire for more aggressive management of symptoms. Interventional spinal procedures are among the top interventional radiological procedures performed in the United States. Establishing future demand also depends on the need for additional evidence about the outcomes and benefits of spinal procedures.

Other potential factors influencing demand for IN are patient and physician knowledge. Development of decision aids for acute diseases, such as stroke, and more elective conditions, such as degenerative disc disease, might be helpful. Education campaigns of health care workers and patients would help appropriately to shape demand. Such efforts, in regards to stroke, are already underway by groups like the Heart and Stroke Association.

Supply of interventional neuroradiology

As noted, the positive results of clinical trials could significantly increase demand for IN services. However, the current number of IN physicians will not be sufficient to meet this need, nor will the number of trainees in the pipeline be adequate.

Additional IN physicians will likely be introduced from three sources. First, there will continue to be broadly trained interventional neuroradiologists capable of providing a large range of procedures similar to the current workforce. These physicians may become more focused on providing IN services exclusively, rather than dividing their time between IN and non-interventional radiological activities. Second, there will be an increase in the number of neurosurgeons that are broadly trained. Finally, there will likely be physicians that train in narrow areas such as vascular surgery for interventional treatment of carotid endarterectomy, and neurologists for the treatment of acute thrombotic stroke.

Whether one of these sources will dominate is uncertain. Although the current IN workforce is primarily from a radiological background, there are many aspects of the field that are more closely aligned with a surgical discipline including significant patient involvement, in-hospital care of very ill patients post-procedure, long-term follow-up of certain cases, significant on-call and after hours obligations, and lengthy procedure times. These features suggest that NS or vascular surgery (for carotid endarterectomy) may more likely become a dominant provider source.

An equally diverse range of physicians could also provide spinal services. Once again, interventional neuroradiologists and neurosurgeons are obvious candidates. Neurosurgeons are already engaged in CS, however, with the development of broadly-trained interventional neurosurgeons, additional spinal procedures will likely be taken on. There may also be broadly-trained interventional radiologists (not sub-specialists to IN).

Non-neurological interventional radiologists, orthopaedic surgeons, and possibly anaesthetists engaging in invasive pain management techniques, would also likely undertake selected procedures. It is also possible that those with medical specialties such as medical oncology or rheumatology could do certain procedures.

Further affecting the health human resources supply is increased demand stemming from research activities. Survey respondents indicate that, on average, research represents only a 10% component of the workweek, while expert focus group participants suggested 30–50% time availability as ideal. Such a shift would have major implications for health human resources.

Discussion about the best health human resources model for research delivery needs to be considered. There may be a desire and historical precedent for most physicians (particularly those in academic centres) to be engaged in research. However, research is a defined skill set requiring specific training and significant allocation of time. Having a small number of adequately supported physicians devoting the large majority of their time to research while the remainder focus on clinical and teaching activities may be a more appropriate model.

Development of future physicians with IN skills will require improved formal post-graduate training programs, likely in the form of fellowships after core certification by the RCPSC. International guidelines for IN fellowships exist, but many physicians have not gone through these programs. Current programs are based in either NS or radiology programs, though a combined program might improve access to the training system.

While enhanced training of residents and fellows will be an important part of increasing supply, there is potentially a large role for advanced practice nurses, as noted in the previous chapters on NS and CS. In addition to other roles, the expert focus group saw an opportunity to involve specialty-trained nurses in the actual procedure. Such models are already in place with interventional cardiology where nurses are trained to perform the initial stages of the procedure and helping with the immediate post-procedure care, such as applying pressure to the intervention site. While not eliminating the need for IN physicians, it would shorten their involvement in each case.

Overall Health Human Resources Implications

The trends discussed previously may have significant implications for IN health human resources:

Overlap between sub-specialties

While immediate expansion of IN is unlikely, the role of IN should be considered in any discussion of NS and CS as there is overlap in disease states and service providers.

Future interventional neuroradiology providers

Future providers of IN services will likely be drawn from a variety of disciplines. The structure of future training programs could help shape the nature of services provided and which types of physicians will perform IN. Whether a common training program for IN could be developed should be explored.

Given that IN is a field in early development and primarily based in academic centres, it is reasonable to expect that research will be a significant area of activity. Therefore, appropriate training, time and funding support should be part of the health human resources planning process.

Involvement of other specialized providers

There is potential for involvement of other specialized health care providers in IN. Such models exist for interventional and surgical cardiac care as well as other areas such as neonatal care. In areas such as spinal procedures for chronic pain, team management models that include other physician disciplines and other health care workers could be considered. Development of a complete IN health human resources model will need to consider these other health care providers.

Changes in disease management

Heath care planners should carefully follow the changing role of IN for acute stroke, aneurysms and carotid artery disease. Within a 3- to 6-year window, there could be significant implications should the standard management of these diseases shift towards IN.

Potential increase in demand

The area of spinal procedures could become a large area of service provision driven by changes in remuneration, changes in public/physician expectations and availability of resources. Because of the large potential demand and associated costs (including burnout of limited IN providers), careful planning for service delivery should be undertaken. Appropriate evidence of cost-effectiveness and clinical benefit are required.

Physician remuneration

A variety of factors suggest that IN services might be appropriate for reimbursement through an alternate funding plan model (AFP). These factors include the frequent call coverage but relatively low volume of procedures, length and complexity of procedures, and potential high demand for involvement in research.

System strategies to increase supply

A non-health human resources component related to increasing supply is reducing system barriers. For example, medical research has supported the development of stroke teams and the Ontario government has been investing in the development of a stroke strategy. Part of this strategy will include having hospitals with resources and systems in place to assess neurological disease and respond quickly. It will be important to incorporate IN services as part of this evolving strategy, including health human resources components such as anaesthesia and nursing, as well as equipment and beds.

Chapter 4—Interventional Neuroradiology

Exhibits

Exhibit 4.1 Core interventional neuroradiology services

I. Cranial

- Intra-arterial thrombolysis
- Carotid angioplasty and stenting
- Treatment of aneurysms – ruptured and unruptured
- Treatment of vascular malformations of the brain and neck
- Treatment of epistaxis
- Treatment of skull-based tumours
- Diagnostic cerebral angiography

II. Spinal

- Vertebroplasty
- Treatment of vascular malformations of spinal cord
- Facet rhizotomy
- Facet injection

Data sources: Expert Focus Group and Provincial Neurosurgical Task Force

Exhibit 4.2 Supply of interventional neuroradiology physicians per site, in Ontario, 2001/02

Site	Number of physicians providing interventional neuroradiology services	Gender	Type of Practice A = Academic C = Community
Toronto (University Health Network)	3	Male = 3, Female = 0	A
Toronto (St. Michael's Hospital)	2	Male = 2, Female = 0	A
Toronto (Sunnybrook and Women's College Health Sciences Centre)	1	Male = 1, Female = 0	A
Ottawa (The Ottawa Hospital)	6	Male = 6, Female = 0	A
Mississauga (Trillium Health Centre)	1	Male = 1, Female = 0	C
Hamilton (Hamilton Health Sciences)	2	Male = 0, Female = 2	A
Kingston (Kingston General Hospital)	1	Male = 1, Female = 0	A
London (London Health Sciences Centre)	4 + 1 neurosurgeon	Male = 3, Female = 2	A
Thunder Bay (Thunder Bay Regional Hospital)	1	Male = 1, Female = 0	C

Data source: Expert Focus Group

Exhibit 4.3 Number of physicians providing interventional neuroradiology services per site, in Ontario, 2001/02

Site	Number of physicians providing core interventional neuroradiology services	Number of physicians adjusted for volume of services provided
Ottawa	24	5.0
Windsor	6	3.5
Hamilton	9	2.5
Mississauga	9	2.0
Sudbury	4	2.5
Thunder Bay	3	0.0
Kingston	10	3.5
London	15	5.0
Toronto (St. Michael's Hospital)	10	4.5
Toronto (Sunnybrook and Women's College Health Sciences Centre)	10	2.0
Toronto (University Health Network)	11	5.0

Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 4.4 Distribution of weekly workload (in hours) for interventional neuroradiologists and academic neurosurgeons aged 40–55 years, in Ontario, 2004

Physician Type	Clinical	Non-Clinical†	Teaching	Research	Other Activities‡	Total*	Weeks Worked Annually
Interventional Neuroradiology	40.45	8.73	6.36	8.27	9.36	72.00	39.75
Academic Neurosurgery	47.13	8.75	5.00	10.60	8.79	83.04	43.69

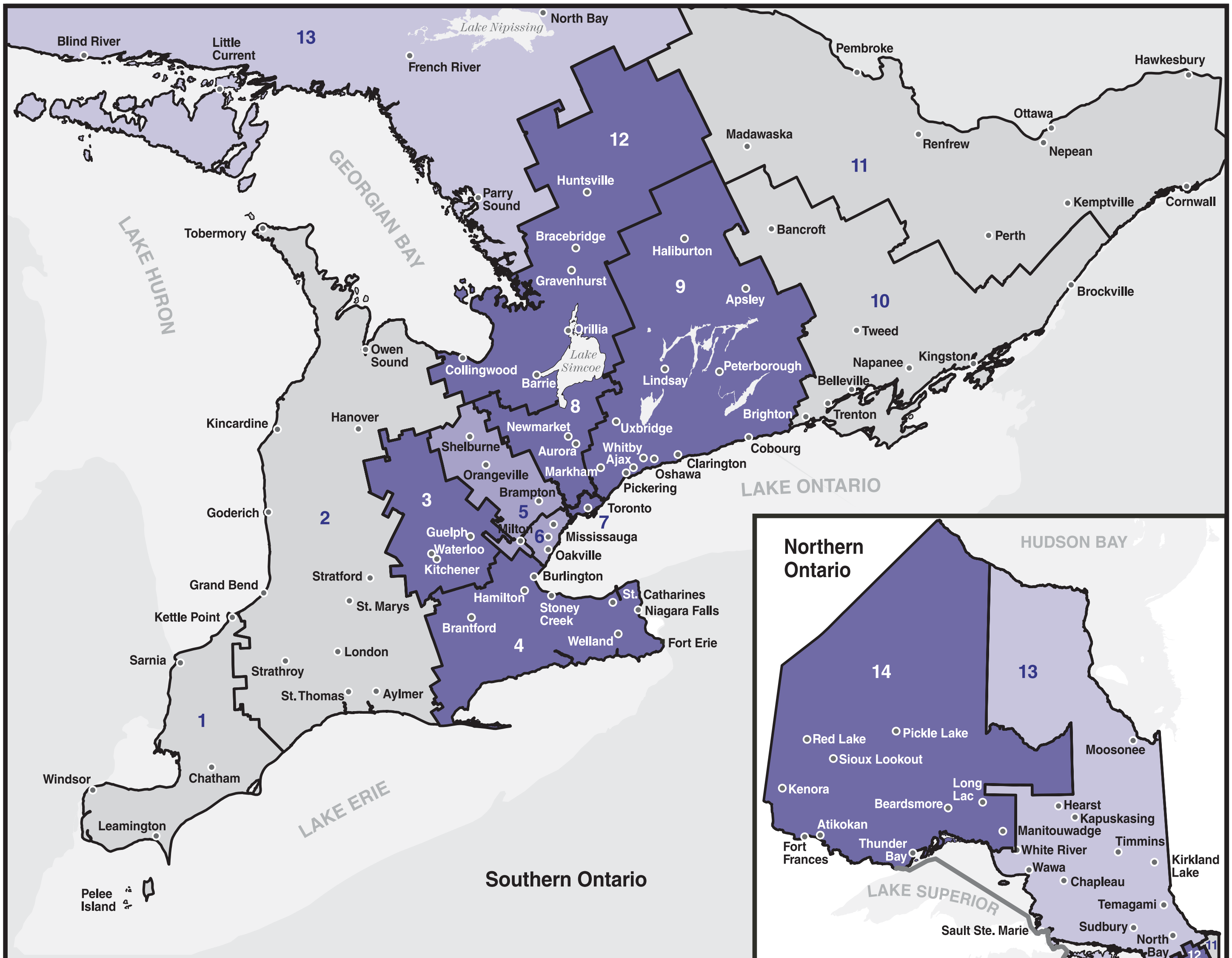
*Numbers represent averages from all survey respondents, therefore, the total hours per week are not sum of other averages, but the average of all sums.

† for example, administration

‡ for example, continuing medical education

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 4.5 Rate of interventional neuroradiology services utilization by Local Health Integration Network, in Ontario, 2001/02



Local Health Integration Networks (LHINs)

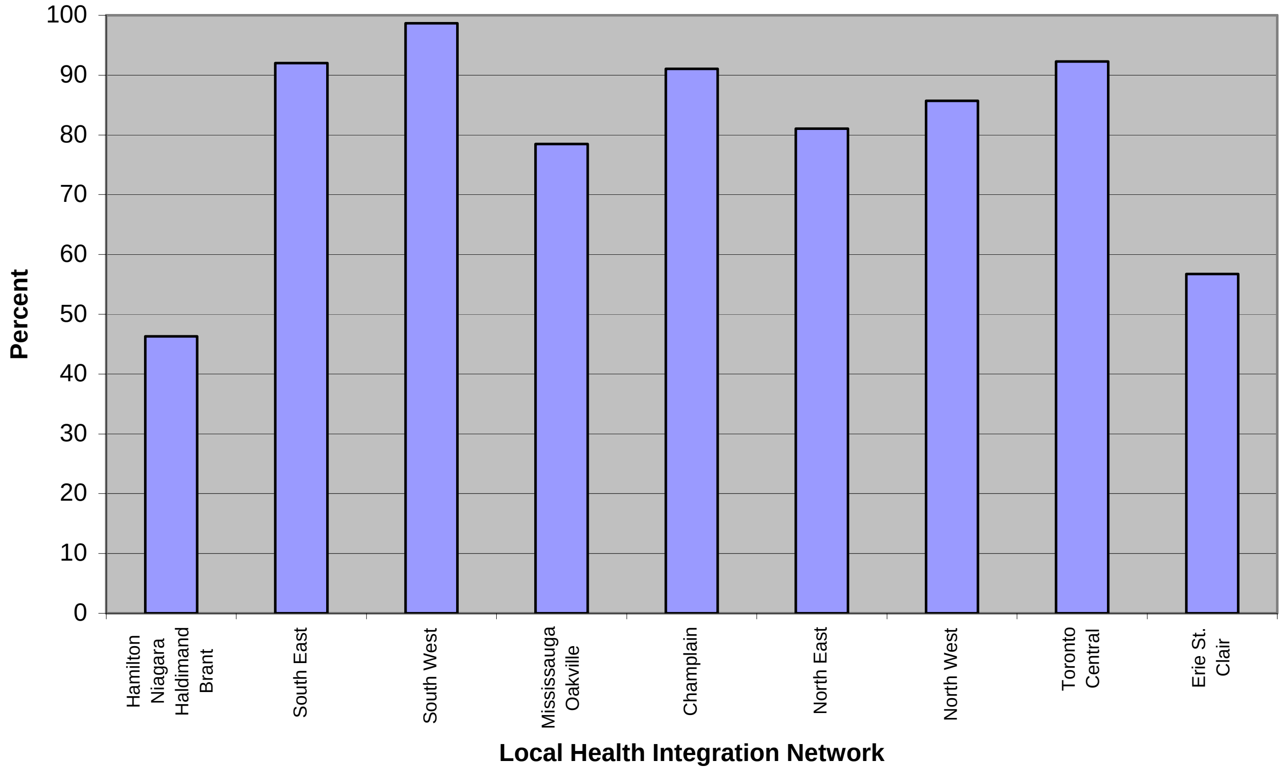
1. Erie St. Clair
2. South West
3. Waterloo Wellington
4. Hamilton Niagara Haldimand Brant
5. Central West
6. Mississauga Oakville
7. Toronto Central
8. Central
9. Central East
10. South East
11. Champlain
12. North Simcoe Muskoka
13. North East
14. North West

Rate of interventional neuroradiology services utilization, by Local Health Integration Network, in Ontario, 2001/02

Comparative rate ratio	Number of LHINs in each category
< 0.75	(7)
0.75 to < 0.9	(2)
1.1 to < 1.3	(1)
≥ 1.3	(4)

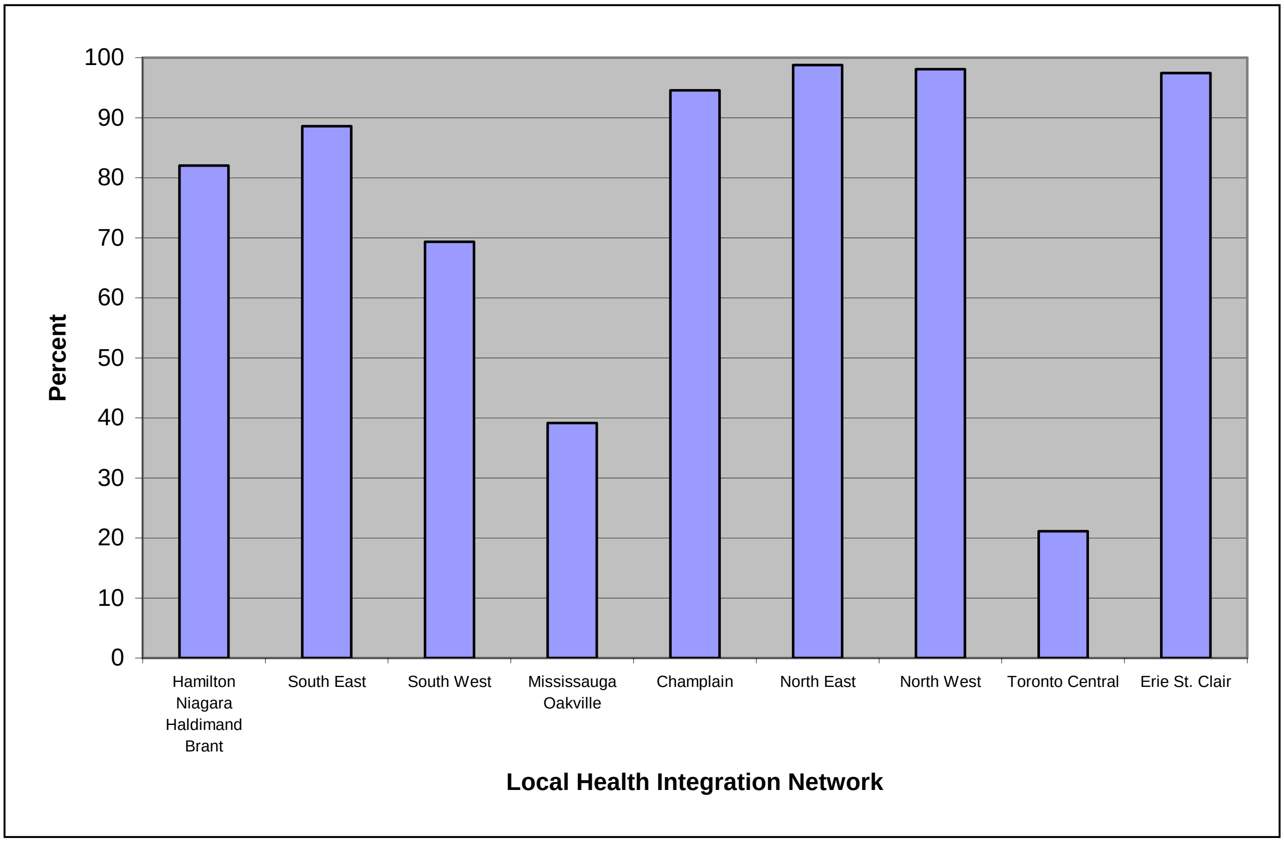
Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 4.6 Localization index for interventional neuroradiology services, by Local Health Integration Network, in Ontario, 2001/02



*Services not provided in LHINs: Waterloo Wellington, Central West, Central, Central East and North Simcoe Muskoka
Data source: Canadian Institute for Health Information—Discharge Abstract Database

Exhibit 4.7 Percentage of interventional neuroradiology cases originating in the Local Health Integration Network in which they were treated, in Ontario, 2001/02



Data source: Canadian Institute for Health Information—Discharge Abstract Database

Chapter 5—Assessment of Current Technology for Neurosurgical Services

Introduction

An assessment of current technology was conducted using the Neurosurgical Workforce 2004 Survey mailed to all neurosurgeons, interventional neuroradiologists and orthopaedic surgeons in Ontario (see Appendix B).

Neurosurgery

From a core list identified through literature review and consultation with the Provincial Neurosurgical Task Force, surgeons were asked to indicate technologies currently used in the main practice setting. For unavailable technologies, a rating score (1 = least urgent to 5 = most urgent) was used to assess level of need. The results are summarized in Exhibit 5.1.

Standard technology to evaluate patients with brain hemorrhage, such as MR angiography, CT angiography and cerebral angiography, is available to more than 85% of neurosurgeons. However, technology to evaluate trauma and emergent patients such as 24-hour MRI is available to only 51% of respondents, and one-third of neurosurgeons identified this as an area of most urgent need. To assess chemical changes in the brain in patients with epilepsy, cancer and trauma, MR spectroscopy is used. While this is available to one-half of neurosurgeons, it was identified as an area of high need by 8%. To map electrical activity in the brain of epilepsy patients being evaluated for surgery, MR encephalography is used. This is available to 18% of surgeons and was perceived by 22% as a technology of high need.

Intraoperative imaging includes surgical navigation equipment to provide a match between the radiological images and the brain or spinal cord. This is accessible to 76% and CT imaging is the most common form available. However, because these images are taken before surgery and because of the potential distortion of the anatomy during surgery, more recent advances include intraoperative CT and MRI to provide images during the procedure. This technology is not widely available—12% of surgeons reported access, and 25% considered it “high need”.

Standard surgical equipment such as operating microscope and ultrasound aspirator were available to more than 95% of respondents. Equipment that provided additional monitoring of patients, such as EEG and evoked potentials, were available to 55% and 65%, respectively. These were not identified as areas of high need.

There was a wide range of availability of implantable devices for spinal surgery. Fixation and stabilization devices such as plates, screws, cages and wires were available to 88% of respondents. However, there was less availability of tissue and biologic materials, such as bone graft substitutes and bone proteins, which provide localized bone growth. Newer technology, such as artificial discs (implants that mimic the human disc and provide increased mobility) was available to 22% of surgeons. The intrathecal baclofen pump, which treats painful spasms in children with cerebral palsy and both adults and children with spinal cord disease, was available to 41% of surgeons.

There is also a wide range in the availability of supportive services and newer, less invasive technology. Neuropathologists assist surgeons by providing ready evaluation of tissue during and after surgery. These specialists were available to 80% of surgeons and were rated as an area of high need by 14%. Minimally invasive radiosurgery using radiation therapy is available to 10% of surgeons while another minimally invasive radiological procedure, kyphoplasty to treat osteoporosis was available to 59%.

Other technology or technological support listed by respondents that were not included in the core set were: intraoperative ultrasound, intracranial pressure monitor and gamma knife.

Complex Spinal Surgery

A striking difference between neurosurgeons and complex spine surgeons is the availability of intraoperative imaging. While all complex spine surgeons reported access to intraoperative CT and MRI, only 12% of neurosurgeons had access to these same technologies. The most recent advancement, the combination of CT and fluoroscopy, provides images in two planes and access is still limited for both groups. This technology is available to only 10% of spinal surgeons and 14% of neurosurgeons.

The study survey responses indicated reduced availability of certain intraoperative equipment. Intraoperative microscopes were available to 77% of surgeons and listed as an area of high need by 10%. Intraoperative evoked potentials allow monitoring of spinal cord function during surgery. This technology is available to 57% of respondents and a high level of need is indicated by 30%.

With regard to implantable devices, the availability of fixation devices and artificial discs was similar in neurosurgeons and complex spine surgeons. However, spinal surgeons reported greater availability of both bone morphogenic proteins and bone graft substitutes compared to neurosurgeons. Bone morphogenic proteins are available to 60% of complex spine surgeons and 29% of neurosurgeons; bone graft substitutes are available to 87% of complex spine surgeons and 55% of neurosurgeons.

The availability of newer minimally invasive procedures was similar between the two groups of specialists. Other technology or technological support listed by respondents that were not included in the core set were: CT, MRI, technicians for intraoperative guidance system, and spinal surgery (Jackson) table.

Interventional Neuroradiology

The core list of technology for interventional neuroradiology (IN) consisted of specialized angiographic equipment to evaluate blood vessels, aneurysms and vascular malformations; devices that treat aneurysms and abnormalities of blood vessels in the brain; and medications such as t-PA to treat blockages of arteries. The results for availability and rating of need are summarized in Exhibit 5.3.

Standard angiographic equipment was available to 92% of respondents. However, more specialized equipment to allow three-dimensional reconstruction of the blood vessels and abnormalities was available to only 58% of respondents, and was identified as an area of high need by 33%. Devices such as microcatheters to allow access to small caliber vessels in the brain, and coils to occlude aneurysms, were available to all respondents. Access to cerebral angioplasty, and stenting devices to treat blood vessels narrowed by disease, was also reported by all respondents. However, cerebral protection devices, an additional technology to minimize complications of this procedure, are available to 83%.

Other technology not included in the core list, but recommended by respondents, included: more MRI, simultaneous subtracted-nonsubtracted fluoroscopy, intracranial stents, vertebroplasty, and RF probe for rhizotomy.

Chapter 5—Assessment of Current Technology for Neurosurgical Services

Exhibits

Exhibit 5.1 Availability and need of neurosurgery technology in Ontario, 2004

	Neurosurgery Technology	Technology Currently Available (%)	Not Available/ Identified as High Need* (%)
Diagnostic neuroimaging	24-hour MRI (magnetic resonance imaging)	51	33
	Cerebral angiography	92	2
	CT (computed tomography) angiography	90	8
	MR angiography	88	4
	MR spectroscopy	53	8
	Magnetoencephalography (MEG)	18	22
Intraoperative neuroimaging	Surgical navigation equipment	76	12
	CT-based image guidance systems	88	8
	Fluoroscopic image guidance systems (e.g., Fluoronav)	67	6
	Intraoperative CT	12	24
	Intraoperative MRI	12	27
	Intraoperative 3D iso-CT fluoroscopic equipment (e.g., Siemens system)	14	10
Intraoperative equipment	Intraoperative EEG (electroencephalogram)	55	8
	Intraoperative evoked potentials	65	8
	Intraoperative operating microscope	98	0
	Intraoperative ultrasound aspirator	96	2
Implantable devices	Artificial disc systems	22	4
	Bone graft substitutes (e.g., coral, demineralized bone matrix protein)	55	8
	Bone morphogenic proteins	29	6
	Spinal fixation and stabilization devices (e.g., titanium, resorbable polymers)	88	6
	Intrathecal baclofen pump	41	14
Other technology and supportive services	Minimally invasive percutaneous vertebral augmentation (e.g., vertebroplasty)	59	6
	Minimally invasive stereotactic spinal radiosurgery (e.g., Cyber Knife technology)	10	20
	Neural stimulator	67	8
	Neuropathology	80	14
	Stereotactic radiotherapy	51	14
	Cerebral blood flow monitor	22	14

*Rated at Level 4 or 5

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 5.2 Availability and need of complex spine technology in Ontario, 2004

	Complex Spine Technology	Technology Currently Available (%)	Not Available/ Identified as High Need* (%)
Intraoperative imaging	CT-based image guidance systems	60	13
	Fluoroscopic image guidance systems (Fluoronav)	37	23
	Intraoperative 3D iso-CT fluoroscopic equipment (Siemens system)	10	10
	Intraoperative CT	100	13
	Intraoperative MRI	100	7
Intraoperative equipment	Intraoperative evoked potentials	57	30
	Intraoperative operating microscope	77	10
Implantable devices	Spinal fixation and stabilization devices-titanium, resorbable polymers	93	3
	Bone morphogenic proteins	60	17
	Bone graft substitutes (e.g., coral; demineralized bone matrix protein)	87	7
	Artificial disc systems	27	13
Other technology and supportive services	Minimally invasive percutaneous vertebral augmentation e.g., vertebroplasty	50	13
	Minimally invasive stereotactic spinal radiosurgery (e.g., Cyber Knife technology)	10	3

*Rated at Level 4 or 5

Data source: 2004 Neurosurgical Workforce Survey

Exhibit 5.3 Availability and need of interventional neuroradiology technology in Ontario, 2004

	Interventional Neuroradiology Technology	Technology Currently Available (%)	Not Available/ Identified as High Need* (%)
Angiographic equipment	Biplane angiographic equipment	92	8
	Three dimensional angiography	58	33
Devices	Microcatheters	100	0
	Coils for cerebral aneurysms	100	0
	Carotid angioplasty and stenting devices	100	0
	Embolization of arterio-venous malformations	92	0
	Cerebral protection devices for angioplasty and stenting	83	8
Medications	Medications such as t-PA	100	0

*Rated at Level 4 or 5

Data source: 2004 Neurosurgical Workforce Survey

Chapter 6—Recommendations

Together, the pressures facing the interrelated disciplines of neurosurgery (NS), complex spinal surgery (CS) and interventional neuroradiology (IN), contribute to the system capacity issues facing neurosurgical services in Ontario. In order to sustain and strengthen this critical provincial resource, the following recommendations are proposed.

Neurosurgery

Ontario's neurosurgeons are barely keeping up with demand and are doing so at very high workload levels for individual neurosurgeons and at significant academic and personal costs. The average neurosurgeon in Ontario:

- Faces high on-call frequencies, often one in every two or three days;
- Has among the highest level of on-call hours of service of all physician groups;
- Works between a range of 73 to 81 hours per week (with younger neurosurgeons working more hours); and,
- Spends only 12% of professional time on research activities even though almost all NS takes place in academic hospitals.

Demand for NS services is predicted to increase with an aging population and the introduction of new surgical procedures. In the near future, there will be a significant drive to recruit new graduates just to keep up with current demand, as a large group of older neurosurgeons retires.

Historically, Ontario has only accepted 1–2 new neurosurgeons into practice per year, despite graduating 6 each year. Most new graduates leave to practice in other jurisdictions due, at least partially, to lack of opportunities within Ontario hospitals. With the current fee-for-service remuneration system, every new neurosurgeon recruited to a hospital often results in a decline in OHIP billings for the existing group of neurosurgeons.

Without a corresponding increase in hospital resources to complement additional recruits, the existing group of neurosurgeons is forced to give up a portion of operating time and access to other clinical tools. While current neurosurgeons do feel that their current workload is excessive, they feel their scheduled operating room time is limited. The areas where they would like additional support from new entrants is for on-call responsibilities and the large burden of non-surgical related clinical cases. Many would also like to allocate their time to non-clinical activities, but funding is limited for research and other academic activities for neurosurgeons. Therefore, they are reluctant to substitute their clinical time (particularly surgical) to pursue these activities.

Replacing the current fee-for-service system with an appropriately tailored alternate funding plan (AFP) would provide opportunity for increased recruitment of neurosurgeons and enable more reasonable workload levels for each neurosurgeon. Neurosurgeons could also be appropriately compensated for their non-clinical activities through the AFP. There is also indication from workforce studies, such as the 2004 National Physician Survey, that new graduates are increasingly interested in new models of compensation such as AFPs.

Recommendation #1
The Ministry of Health and Long-Term Care (MOHLTC) should implement comprehensive AFPs for neurosurgeons. Data should be collected from the outset to evaluate the impact of any new compensation model. Information should include recruitment and retention issues as well as volume and type of activity (clinical and non-clinical).

There is an immediate opportunity to increase the supply of neurosurgeons. The American Board of Neurological Surgery (ABNS) ruled that Canadian neurosurgical training would no longer be recognized in the United States, and applies to residents who started training after July 16, 1997. Given the long duration of neurosurgical training time, the impact of the ABNS ruling against Canadian graduates is just now being realized. Accordingly, there is an opportunity to capitalize on this situation by developing an appropriate recruitment package for new graduates that would help ensure a strong NS health human resources platform for many years.

Recommendation #2
The MOHLTC and other involved stakeholders should act immediately on the opportunity to capitalize on the ABNS decision to bar entry of any foreign trainee into the US, thereby ensuring a larger recruitment pool of Ontario NS trainees.

Given the urgent need to offset current workload pressures and the need to replenish the existing workforce in the near future, the key question is how many more neurosurgeons are needed.

Ultimately, the "correct" number of any health care worker needs to reflect competing needs within the health care system and beyond, and is a societal matter that must consider community priorities and ethical issues in decisions regarding the health demands of the population.

Determining the number of neurosurgeons that might be needed by the province is a complex question impacted by a number of contributing factors, for example:

- What is a reasonable total workload for a neurosurgeon?
- What should the split of clinical versus non-clinical versus academic time be?
- How sub-specialized will neurosurgeons become and how does this impact on the scope of practice?
- How will the delivery of care differ in the future?
- What are the expectations and needs of the public?

This project created a dynamic tool based on different scenarios to help predict the number of neurosurgeons that would be needed relative to the existing situation. Using a benchmark of 60 hours per week, a moderate increase in demand for services, and the role of alternate providers to assist with workload, it was estimated that an additional 10 neurosurgeons would need to be recruited for the province immediately. This is consistent with the findings of Dr. Charles Wright,[3] who recommended recruiting six more neurosurgeons, based on a physician to population size approach.

As data collection improves and additional resources are allocated to the task of health human resources modeling, more robust and sophisticated predictions can be made.

Recommendation #3
The MOHLTC should facilitate the recruitment of 10 additional neurosurgeons for the province in the next 2–3 years. This would allow a reduction in hours worked per week (from 73–81 to 65–70). It would also replace the predicted departure of 1–2 neurosurgeons in this time and allow for anticipated growth in demand for cranial neurosurgical services.

Complex Spinal Surgery

The pressures facing CS are different than those for NS. Whereas NS is currently able to balance demand with supply, there are significant wait lists for elective CS and even for initial assessments. Furthermore, whereas the demand for NS is expected to moderately increase (driven primarily by an aging population), the demand for certain types of CS is expected to rapidly expand.

Throughout the study, the barriers to accessing spinal surgery consultation were raised frequently. There is currently no mechanism to track, measure and compare the wait times. Like most services, the data resides within individual physician offices and there is no standard definition for wait times.

Recommendation #4
The MOHLTC should incorporate CS as part of the evolution of the Access/Wait Times Project, similar to the approach to hip and knee replacement. In order to better define CS, the Wait Times Project should: 1) Develop a mechanism to track, measure and compare wait times; 2) Develop a standard mechanism/model to access care; 3) Assess the wait time (prospective vs. retrospective) at different points along the pathway; and, 4) Address the bottlenecks via health human resources solutions (e.g., mix of physician to non-physician, training impacts) and infrastructure solutions (diagnostic and therapeutic).

In many cases, the greatest delay for CS patients is for a first assessment by the surgeon following referral from a family physician or other professional. These patients, while not necessarily inappropriately referred, may not be amenable to surgery. Patients wait for long periods of time, only to be told that they are not appropriate candidates for surgery. Only about 5% of spinal consults lead to surgery, compared with 30–40% for cranial-related referrals.[2]

An assessment process that includes other health care professionals could expedite the selection for patients that are appropriate for spinal surgery. This would serve two purposes: 1) To reduce wait times for assessments; and, 2) To minimize the already stretched time commitments of spinal surgeons. This would allow the spinal surgeons to focus their time in the operating room and on other activities for which no other care provider can offer the same type or level of service.

Recommendation #5
The MOHLTC should establish regional, multidisciplinary teams (including advanced trained nurses, family physicians and physiotherapists) to perform assessment for patients referred for potential CS, thus improving access to care.

Another significant problem identified in this study is the lack of a clear definition of CS and information about the type and number of procedures performed within this definition. Currently, many CS procedures are aggregated with other procedures in different databases. Accurate information would improve monitoring of supply and demand for services and guide appropriate resource allocation including physician remuneration. The MOHLTC and spinal surgeons should develop a clear definition of CS to enable appropriate data collection of the relevant procedures.

Interventional Neuroradiology

Within neuroscience, IN is an emerging area of sub-specialization. Located almost exclusively in large urban settings (primarily in academic health science centres), only a small number of physicians provide these services. This is related to the high degree of physician sub-specialization (with only a handful of practitioners in the province), and to the need for separate procedure suites with specifically trained interventional staff and costly specialized equipment. As a result, there are significant regional disparities in access to these services.

One example is the regional disparity in quality of, and access to, stroke services. In Thunder Bay, neuroradiological services are limited. As a result, time-sensitive clot-busting drugs delivered only by interventional neuroradiologists, available in major centres, are not given to stroke patients in Thunder Bay. Furthermore, transfer of patients to other referral centres is not a feasible solution due to the time limitations for the drug to be effective.

The role of IN has the potential to rapidly expand within the next few years. Such expansion will require evidence-based indications of clinical benefit, a sufficient supply of trained physicians and appropriate supporting infrastructure. Attention to policy and planning of IN services is required to gain an in-depth understanding of the regional variations and the clinical benefits of expanding services.

Recommendation #6
The MOHLTC should establish a province-wide strategy for IN that identifies and addresses the variation in practice across the province, in order to ensure standard, equitable access to services.

Currently, CS is provided almost exclusively by radiologists. However, given the clinical complexity of the patients (including post-procedural care) and the predicted increasing volume of cases there may be a greater role for other physicians such as neurosurgeons.

Recommendation #7
The MOHLTC health human resources planning for IN should consider that neurosurgeons will likely be involved along with radiologists in this field.

Resources to ensure a critical mass of IN expertise and service provision include:

- Access to anaesthesia;
- Access to technology e.g., diagnostic tools, medical devices, surgical equipment;
- Intensive Care Unit beds and/or critical care nurses; and,
- Dedicated budgets with clear plans for consistent service provision.

Neurosurgical Technology

While basic neurosurgical technology is available to the three groups of specialists, the expert focus groups identified barriers to regular access to this equipment, as well as to more advanced equipment.

The adoption of new technology needs to be guided by evidence. The Ontario Health Technologies Assessment Committee (OHTAC) conducts systematic reviews to determine the appropriateness of different technologies. Physicians have an important role to play in the collection of relevant information.

Neurosurgeons have access to standard equipment for the imaging of arteries. However, they have stated that there is a need for 24-hour magnetic resonance imaging (MRI) and advanced intraoperative imaging. They have also identified access limitations to functional neuroimaging such as magnetoencephalography (MEG) for epilepsy surgery and MR spectroscopy.

Complex spine surgeons have access to advanced intraoperative imaging but lack more advanced technology such as artificial discs and bone morphogenic proteins. There is also a need for less advanced monitoring equipment such as intraoperative evoked potentials. Interventional neuroradiologists have access to equipment for core procedures but experience access issues for more advanced imaging such as three-dimensional angiography.

Future NS procedures will require advanced technology, specialized training and a larger workforce. There will be an increasing use of technologies including artificial discs, coils for aneurysm, angioplasty and stenting. The use of evidence-based medicine and cost/benefit analysis are critical tools in the decision to incorporate new equipment and technology into practice. In terms of access and cost, technology is a key component of neurosurgical services and planning. Health human resources planning should not be divorced from these issues.

Despite the established clinical benefits of many neurosurgical devices, providers must rationalize access because there is no dedicated funding for these devices. Capital equipment, for the most part, is purchased by hospitals within their global budget envelope.

Neurosurgical devices, such as spinal implants, are not funded. In contrast, the government funds implants for other services, such as stents for arteries and joints for hip and knee procedures. The absence of funding for devices is an issue that is particularly acute and profound for spinal surgery.

Recommendation #8
Where the evidence supports effectiveness, the MOHLTC should fund neurosurgical technologies (e.g., spinal implants, osteobiologics including bone morphogenic proteins, radiological devices) in a manner that would attract and retain neurosurgeons and enable them to provide state-of-the-art care for Ontarians.

System-Wide Policy Options

Based on the overall findings of the study, five key policy options were identified:

1. Provincial disease management strategy for neurosurgical services

With ongoing resource constraints in the health care system, it is essential to identify services that struggle to maintain appropriate access when delivered as part of global hospital budgets that, by virtue of resource intensity (people, supplies, technology or space) and complexity,.

This is the premise of the provincial disease management strategy currently being considered by the MOHLTC. Criteria for determining inclusion cover services that:

- Require highly specialized, high-cost equipment, supplies or space (i.e., radiation machines, dedicated operating rooms);
- Involve new and emerging technologies requiring systematic oversight and evaluation;
- Likely require provincial consolidation or redistribution of activity in order to meet minimum volume or quality service thresholds;
- Encompass a complex chronic disease journey involving repeat outpatient and inpatient care across multiple organizations or regions;
- Require provincial standards and resource planning across Local Health Integration Networks to ensure efficiency, quality and optimal performance of locally administered programs;
- Should be purchased through standardized provincial efforts instead of one-offs within regions.

Together, these six criteria are intended to capture services that require a sustainable supply and critical mass of highly specialized health care providers. For the most part, CS, in particular, satisfies all six criteria.

A unified, provincial disease management strategy for CS will establish the mechanism for determining need, acuity and wait times leading to improved service delivery. Means to make neurosurgical specialties, which are primarily centred in large urban settings, accessible to the rest of the province should be considered, especially for interventional neuroradiology (IN). This may include physician and patient education, formal corridors of access, delineation of catchment areas and regional referral patterns, use of tele-medicine/tele-imaging, and tailoring or enhancing services such as Criti-Call.

2. Recognize regional variation

Currently, rates of utilization for neurosurgery (NS) are similar across the province, however, there are significant variations in CS and IN. There are also defined patterns of patient migration for services. The reasons for variations in utilization should be explored and any differences that are due to barriers in access should be addressed. Allocation of resources to a given centre should reflect the role of that centre in meeting the needs of adjacent regions or even the province as a whole.

3. Expanded role for other physicians and health care professionals

As highlighted in the discussion of CS, the office setting is a significant and growing draw on a surgeon's time. Options for improvement include using other appropriately trained health professionals to screen and manage the consultations, and education of family physicians and others making the referrals. The role of advanced trained nurses or other health care providers could also be explored in the hospital setting, such as post-operative or intra-operative care.

4. Training program development and funding

Many areas of neuroscience require additional fellowship training after the core five years of post-graduate medical education. Training needs to be made more available, with appropriate funding and greater accessibility to physicians from different disciplines.

5. Future health human resources modeling

With insufficient data, it is difficult to identify the physicians involved in neurosurgical services and the nature and volume of services provided. Collection of standardized, high quality data about providers (including their activity) and the needs of the population should be undertaken on an ongoing basis. Such data should include the potential role of other health professionals (e.g., nurse practitioners or physician assistants) and demands on specialized hospital resources.

The MOHLTC, as well as centres with relevant expertise, such as the Institute for Clinical Evaluative Sciences (ICES), should enhance capacity to do dynamic health human resources modeling for neurosciences.

Future health human resources modeling needs to consider factors such as the increased numbers of female practitioners and the potential introduction of alternate payment plans, both of which are known to have significant implications in other surgical specialties.

6. Work hour limitations

All the neurosurgical specialties studied in this report routinely worked in excess of the one on-call day in every five days recommended by the Canadian Medical Association (CMA). There is also growing discussion about the impact of prolonged working hours and concern about physician and patient safety. A critical volume of providers should be organized to provide on-call services such that the burden is no greater than the CMA recommendation.

Appendix A—Provincial Neurosurgical Task Force Project Charter

Task Force Purpose

1. Identify system-level medical staff and technology issues that impact on access to neurosurgical services, including neurosurgery (NS), complex spinal surgery (CS), and interventional neuroradiology (IN).
2. Make short and long-term recommendations to address these access issues, including funding recommendations.

Project Goals/Objectives

The task force will focus on access to medical staff and technology for common conditions within NS, CS, and IN. Recommendations will be made on short- and long-term solutions in order to improve access across Ontario.

The task force's objectives include:

- Documenting state-of-the-art physician services and technologies in North America and Europe;
- Benchmarking the Ontario situation against these standards;
- Determining current system capacity for these services;
- Identifying system-wide issues that may be limiting access;
- Defining medical staffing needs and care model(s);
- Identifying case types that should be considered for special funding;
- Developing a long-term plan to address access issues over the next five years; and,
- Recommending funding mechanisms for services and the introduction of new technology.

Guiding Principles

Recommendations from the task force will reflect:

- Reasonable medical staff workload;
- Maintained or enhanced patient outcomes;
- A system-wide approach based on reliable and accurate data;
- A scope limited to NS, CS, and IN; and,

Consideration of international state-of-the-art practices, and evidence for medical services and technology.

Appendix B—How the Research was Done

A number of different methodological approaches to neurosurgical sciences can be adopted. One option is to consider specific disease entities such as stroke or cancer. Another possibility is to view it strictly from a physician perspective and draw clear distinctions between the different providers such as vascular surgeons, radiologists, neurosurgeons etc. A procedural approach such as minimally invasive surgery versus open surgery versus interventional could be applied.

Given the health human resources orientation of this project and with the approval of the task force, the neurosciences were viewed as the collection of physicians providing services in the clinical areas of neurosurgery (NS), complex spine (CS), and interventional neuroradiology (IN).

Data Sources

Five sources of data were used by the Institute of Clinical Evaluative Sciences (ICES) to help develop the health human resources model and predict future implications (see Table B.1).

Data Analysis

Calculation of full-time equivalency and adjustment for service volume

Calculation of full-time equivalency (FTE) in the ICES physician database is based on an approach developed and utilized by CIHI. In addition, this study modified the results of the CIHI hospital databases by adjusting for the volume of services provided. The volume of relevant procedures (the analysis was conducted separately for the three areas of interest) for each physician in a given centre was determined for 2002. If a physician provided fewer than six procedures, or less than 5% of the total procedures for the centre, s/he was not counted. A physician who provided between 5.1% and 9.9% of the total procedures was assigned as a 0.5 FTE. A physician who provided 10 to 14.9% of the total was assigned as a 0.75 FTE. A physician providing 15% or more of the total services was counted as a whole FTE.

While this approach provides a useful comparative approach for clinical services, it undervalues the research, academic and other non-clinical roles that a physician may provide. It also relies on the accuracy of the initial coding of the procedures. For some of the newer procedures (including IN and CS) it is possible that several (including those that are not core procedures) are billed under the same code, which would over-inflate the volumes and, thus, the number of providers. Another reason for overestimation is that calculation of FTE by location does not weight larger volume centres higher relative to smaller.

The advantage of the FTE approach is that it does not rely on the self-reported presence of physicians. It also accounts for physicians that may only be part-time clinicians or engaged in other clinical areas. For example, most of the IN physicians reported only one-third of their time engaged in IN services.

Utilization of Local Health Integration Networks

Regional differences in utilization of neurosurgical services were illustrated at the level of Local Health Integrated Network (LHIN)—14 geographic areas that form the basis the provincial government's efforts to plan, coordinate and manage service delivery. They provide a useful structure for studying the heavily centralized neurosurgical services featured in this report. The initial development of the LHINs, and the methodology for studying resource differences, were done at ICES.

Workforce survey

To better understand the neurosurgical workforce, a tailored survey was mailed to three groups: neurosurgeons, interventional neuroradiologists and orthopaedic surgeons. For the latter group, only those engaged in CS (defined as spinal cord injury or myelopathy {disease or disorder of the spinal cord};

extradural tumours or infections of the vertebral column; spinal deformity; instrumentation of the spine involving more than two levels; complex congenital pathology of the spine; or disorders of the craniocervical junction) were requested to complete the survey.

Based on the national Janus workforce survey of family physicians conducted by the College of Family Physicians of Canada, the comprehensive neurosurgical survey produced a profile of current practice patterns, major practice stresses, and future career directions (with a two-year forecast).

Response rates were as follows:

- Neurosurgeons—78% (49 out of 63);
- Interventional neuroradiologists—57% (12 out of 21);
- Orthopaedic surgeons—76% (341 out of 447) of which 30 identified themselves as complex spinal surgeons.

Neurosurgeons that indicated 75% or more of their time was engaged in CS, IN or pediatric NS, were recategorized accordingly for analysis.

Development of a dynamic forecasting model

The utilization-based model used in this report builds on the access modeling project developed by Dr. Ben Chan, former ICES scientist, used in policy initiatives and health human resources planning strategies such as the 2001 Ontario Ministry of Health and Long-Term Care Expert Panel on Health Professional Human Resources.

First, the demand side of the system is framed. Expert focus groups identify the main diseases and surgical procedures treated within the field being studied. To estimate current demand, the expert group defines the amount of time required to deliver these services. Current service utilization is determined from available databases. Procedure time, combined with supply (determined by workforce surveys), allows an estimation of the current workforce supply. The expert group then predicts future demand for procedures, taking into account population demographics, disease incidence rates, new technology, medical knowledge etc.

The gap between predicted demand and current supply represents the required neurosurgical services. By varying possibilities on the demand side (e.g., increasing disease incidence) or supply side (more time spent researching), different scenarios can be explored.

Definition of services

The model developed here started with the services of interest rather than a particular physician group. Through this process, the interrelated areas of CS, IN and NS became evident.

Within each of these three areas, an expert focus group, representing different disciplines and practice locations, identified seven to ten core services believed to characterize the majority of that surgeon's clinical activity (see Table B.2).

According to the expert focus group, the core of NS can be categorized as cranial, spinal or a small number of other (e.g., carotid endarterectomy) procedures. Similarly, IN can be similarly categorized as either cranial or spinal procedures. While no clear definition of CS exists, the core procedures are defined as those performed only by orthopaedic surgeons, only by neurosurgeons, or by both disciplines.

In many respects evaluating health human resources issues for neurosurgeons is a better defined undertaking than the other two clinical areas. The discipline of neurosurgeons has long been uniquely recognized and most databases, such as Ontario Health Insurance Plan (OHIP), Canadian Institute for Health Information (CIHI) and ICES Physician Workforce Database (IPWD), clearly identify this group, thus, contributing more extensive information about the supply of neurosurgeons.

Determination of utilization

Having defined the clinical areas of interest, the current volume of services was determined through databases. The CIHI hospital database provided the best level of information, and relevant ICD-10 codes were identified with assistance from physicians and expert hospital-based coders responsible for entering the information. The OHIP database was also utilized to help provide trend analysis (CIHI data was only available for 2002) and to help validate CIHI. Generally OHIP data failed to provide sufficiently discrete codes. Where CIHI and OHIP were close, the higher value was selected.

Total services were then broken down by provider type (for both CIHI and OHIP). For CS, only services provided by orthopaedic surgeons and neurosurgeons were included. For IN, only radiologists and neurosurgeons were considered. For NS, only neurosurgeons were considered.

Both CIHI and OHIP databases have basic patient information and the services for patients under age 19 were segregated. A separate search under the CIHI physician designation of pediatric neurosurgeons was also performed.

CIHI and OHIP databases provided the total volume of services supplied for each of the core procedures. The expert focus group then provided the total amount of time required for each procedure including operative time, post-operative time, pre-operative assessment and follow-up visits. The unit of time was hours (or fractions thereof). By multiplying the number of procedures by the complete time needed to provide the service, a total number of hours of annual services utilized was determined.

Determination of services supplied

To assess the nature of physician services, information from the workforce survey was analyzed to determine the weekly amount of clinical activity provided by physicians and the number of weeks worked per year. Information about other professional activities such as teaching and research were also analyzed. By multiplying the number of hours of clinical work per week by the number of weeks worked per year, a total number of clinical hours per physician was determined.

By organizing the respondents by age categories, the average number of clinical hours per year was determined. This was then multiplied by the number of physicians in that age category currently in practice. This number was taken from the Charles Wright report.

The total number of clinical hours for all providers of all ages was determined. Only a portion of these hours was spent on surgical services. The expert focus group estimated that 40% of their clinical time was spent on surgically-related activities (including pre- and post-surgical time). The model estimated that 35% of the total time was spent on surgical-related activities.

Through the common unit of hours, it was possible to model the interplay between projected utilization and projected supply based on the input of the expert focus group. Unfortunately, it was only possible to model NS. Administrative level data about specific CS and IN service was difficult to identify given the lack of distinct fee codes or ICD-10 classification. The situation was further complicated for IN given the small numbers of providers and the small volume of core procedures.

Limitations

The following factors should be considered when interpreting the results of this project.

Low physician numbers

The most significant issue is the highly limited number of physicians engaged in supplying NS, CS and IN. In the IPWD, there are almost 10,000 family physicians and several hundred internists and general surgeons. In contrast, there are only 74 neurosurgeons. The expert focus group identified approximately

20 interventional neuroradiologists a few dozen complex spinal surgeons.

With such small numbers, the data are prone to variability and are insufficient for significant subset analysis. Trying to combine factors such as age, location and gender excessively stretches the data, which limits the strength of the predictive model, and reduces the number of scenarios that can be confidentially provided.

Identifying sub-specialties

Another limiting factor is the challenge of identifying complex spinal surgeons and interventional neuroradiologists in traditional databases like the IPWD, OHIP, CIHI or the OMA health human resources surveys. Consequently, both supply and demand information is difficult to identify and extract.

Despite these disadvantages, it should be noted that the survey and focus groups are one of the first health human resources initiatives to specifically focus on these three groups as distinct entities with unique health human resources issues.

Appendix B – How the Research was Done

Tables

Table B.1 Description of data sources

	Data Source	Source	Features
1	ICES Physician Workforce Database (IPWD)	ICES	Most of the physicians studied in this report work in a fee-for-service (FFS) model. They submit a bill for every insured clinical activity they perform in order to receive payment. This submission contains basic information about the physician and the service provided. The Institute of Clinical Evaluative Sciences (ICES) created a database of the physician workforce by incorporating elements from several standard data sources including the Ontario Health Insurance Plan (OHIP), the Ontario Physician Human Resources Data Centre (OPHRDC) and the Southam Medical Database. Combined, this dataset can provide basic demographic and practice profile information about physicians by specialty. IPWD is routinely updated and has been used for a variety of health human resources projects for the MOHLTC.
2	Mail-based survey sent to relevant physicians and administrators	Modeled, with permission, after the Janus survey of family physicians conducted by the College of Family Physicians of Canada. The ideal data source was the National Physician Survey, but its results were not available until 2005.	Workforce survey sent to all Ontario neurosurgeons, interventional neuroradiologists and orthopaedic surgeons (self-identified for complex spine). All survey results were coded to ensure anonymity and results used only in aggregate and only where numbers are large enough to avoid identification of particular physicians. Over 75% response rate was achieved for all groups.
3	Expert Focus Groups for neurosurgery, complex spine, and interventional neuroradiology	Comprised (when possible) of academic and community physicians from centres across the province	Focus groups held to identify current and future issues affecting physician supply of neurosurgical services. Information about demand and supply was gathered. Participants of focus group listed in Table B2.
4	OHIP database and Canadian Institute for Health Information (CIHI) database	OHIP and CIHI through ICES under specified contracts and with restricted use	Large administrative databases used to gain insight into current level of supply of different neurosurgical services. Contains information for every hospital admission and same-day surgery. The database has basic demographic information about the patient (e.g., age and gender), the hospital (name, location), the reason for the visit, and the physicians involved in the visit. The reason for the visit is organized with the International Classification of Disease (ICD-10).
5	Other health human resources data sources	ICES	Including the Ontario Medical Association's annual physician workforce survey and other recent studies looking at neurosurgeons and health human resources issues

Table B.2 Participants in expert focus groups

Participant	Specialty	Organization
Neurosurgery Focus Group		
Dr. Susan Brien	Neurosurgeon	Hotel-Dieu Grace Hospital, Windsor
Dr. Jim Drake	Neurosurgeon	The Hospital for Sick Children, Toronto
Dr. Howard Lesiuk	Neurosurgeon	The Ottawa Hospital
Dr. F.A. Ogundimu	Neurosurgeon	Sudbury Regional Hospital
Dr. Kesh Reddy	Neurosurgeon	Hamilton Health Sciences
Dr. Michael Schwartz	Neurosurgeon	Sunnybrook and Women's College Health Sciences Centre, Toronto
Dr. Chris Wallace	Neurosurgeon	University Health Network, Toronto
Complex Spine Focus Group		
Dr. Michael Fehlings	Neurosurgeon	University Health Network, Toronto
Dr. Garth Johnson	Orthopaedic Surgeon	The Ottawa Hospital
Dr. Eric Massicotte	Neurosurgeon	University Health Network, Toronto
Interventional Neuroradiology Focus Group		
Dr. M. Goyal	Radiologist	The Ottawa Hospital
Dr. Steven Lownie	Neurosurgeon	London Health Sciences Centre
Dr. Walter Montanera	Radiologist	St. Michael's Hospital, Toronto
Dr. Karel TerBrugge	Radiologist	University Health Network, Toronto
Dr. Chris Wallace	Neurosurgeon	University Health Network, Toronto

References

1. Woodrow S, O'Kelly C, Wallace C. Practice patterns of recent neurosurgical graduates in Canada: how do the numbers add up? Presented at the 39th meeting of the Canadian Congress of Neurological Sciences, Calgary, June 2004.

2. Recommendations for improved access to neurosurgery in Toronto. August 2003. Toronto District Health Council, http://www.tdhc.org/pdf/REPORT/Recommendations%20for%20Improved%20Access%20to%20Neurosurgery%20in%20Toronto.pdf

3. Wright, CJ. Achieving stability for neurosurgery in Ontario. October 2003, submitted to the Physician Services Committee of the Ministry of Health and Long-Term Care.
4. Hugenholtz, H. Neurosurgery workforce in Canada, 1996–2011. *Can Med Assoc J* 1996; 155(1):39–48.

5. Ontario Medical Association Health Human Resources Survey, 2003.

6. Neurosurgery Expert Focus Group Meeting.

7. Complex Spinal Surgery Expert Focus Group Meeting.

8. Interventional Neuroradiology Expert Focus Group Meeting.

9. Molyneux A, Kerr R, Stratton I, et al. International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2,143 patients with ruptured intracranial aneurysms: a randomized trial. *Lancet* 2002; 360: 1267–74.

10. International study of unruptured intracranial aneurysms investigators. Unruptured intracranial aneurysms: risk of rupture and risks of surgical intervention. *New England Journal of Medicine* 1998; 339: 1725–33.

11. Tenenhouse A, Joseph L, Kreiger N, Poliquin S, Murray TM, Blondeau L, et al. CaMos Research Group. Estimation of the prevalence of low bone density in Canadian women and men using a population-specific DXA reference standard: the Canadian multicentre osteoporosis study. *Osteoporosis International* 2000; 11(10):897–904.

12. Riggs, BL, Melton III, LJ. The worldwide problem of osteoporosis: insights afforded by epidemiology. *Bone* 1995; 505S–511S.

13. Patchell R, Tibbs PA, Regine WF, et al. A randomized trial of direct decompressive surgical resection in the treatment of spinal cord compression caused by metastasis. Abstract presented at 2003 American Society of Clinical Oncology ASCO meeting.

14. Guyer R, Ohnmeiss DD. Intervertebral disc prostheses. *Spine* 2003; 15S: S15–S23.

15. Parkinson Society Canada (www.parkinson.ca/pd/parkinson.html)

16. Hauser WA, Hesdorffer DC. Epilepsy: frequency, causes and consequences. New York: Demos Press; 1990.

17. Kwan P, Brodie MJ. Early identification of refractory epilepsy. *New England Journal of Medicine* 2000; 342:314–19.

18. Statistics Canada. Causes of death 1993. Cat. 84–208 (annual).

19. Hodgson C. Prevalence and disabilities of community-living seniors who report the effects of stroke. *CMAJ* 1998; 159 (6Suppl): S9–S14.

20. Chan B, Hayes B. Cost of stroke in Ontario, 1994/95. *CMAJ* 1998; 159 (6Supp);S2–S8.

21. Moore R, Nao Y, Zhang J et al. Economic burden of illness in Canada 1993. Health Canada, Laboratory for Disease Control, http:/www.hwc.ca/hpb/lcdc.

22. The National Institute of Neurological Disorders and Stroke r-tPA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. *New England Journal of Medicine* 1995; 333:1581–87.

23. del Zoppo GJ, Higashida RT, Furlan AJ et al. PROACT: a phase II randomized trial of recombinant pro-urokinase by direct delivery in acute middle cerebral artery stroke. *Stroke* 1998; 29: 4–11.

24. Foulkes MA, Wolf PA, Price TR, Mohr JP, Hier DB. The stroke data bank: design, methods, and baseline characteristics. *Stroke* 1988; 19:547–54.

25. Ontario Physician Workforce Database

26. Ontario Medical Association Health Human Resources Survey, 2003.