A novel approach for the accurate prediction of thoracic surgery workforce requirements in Canada

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Objective: To develop a microsimulation model of thoracic surgery workforce supply and demand to forecast future labor requirements.

Methods: The Canadian Community Health Survey and Canadian Census data were used to develop a microsimulation model. The demand component simulated the incidence of lung cancer; the supply component simulated the number of practicing thoracic surgeons. The full model predicted the rate of operable lung cancers per surgeon according to varying numbers of graduates per year.

Results: From 2011 to 2030, the Canadian national population will increase by 10 million. The lung cancer incidence rates will increase until 2030, then plateau and decline. The rate will vary by region (12.5% in Western Canada, 37.2% in Eastern Canada) and will be less pronounced in major cities (10.3%). Minor fluctuations in the yearly thoracic surgery graduation rates (range, 4-8) will dramatically affect the future number of practicing surgeons (range, 116-215). The rate of operable lung cancer varies from 35.0 to 64.9 cases per surgeon annually. Training 8 surgeons annually would maintain the current rate of operable lung cancer cases per surgeon per year (range, 32-36). However, this increased rate of training will outpace the lung cancer incidence after 2030.

Conclusions: At the current rate of training, the incidence of operable lung cancer will increase until 2030 and then plateau and decline. The increase will outstrip the supply of thoracic surgeons, but the decline after 2030 will translate into an excess future supply. Minor increases in the rate of training in response to short-term needs could be problematic in the longer term. Unregulated workforce changes should, therefore, be approached with care. (J Thorac Cardiovasc Surg 2014;148:7-12)

The potential oversupply of thoracic surgeons in Canada is a growing concern. Accurately predicting fine-level workforce requirements has become increasingly important as specialty medical societies attempt to predict workforce needs and as government agencies work to ensure appropriate resource allocation on a regional and national level. Forecasting long-term workforce needs is challenging and requires a thorough understanding of the factors that affect both the supply of, and the demand for, surgeons. These factors include surgeon demographics and scope of practice, the volume of surgical procedures, surgeon migration, and overall population demographic change.[1] Although the demand for surgical services can vary according to population demographic change, variations in the incidence of disease, and the implementation of new technologies, the surgeon workforce supply will be dependent on the existing number of surgeons and their collective productivity.[2,3] Productivity can be affected by age, gender, and resource availability.[2] Furthermore, an imbalance in supply will often be due to long training requirements, resulting in a "lag phase" for surgeons entering the labor market. This phenomenon was evident in the field of cardiac surgery and was likely attributable to the plateau in the rates of cardiac bypass graft surgery and an exponential increase in medical and interventional treatment of coronary artery disease.[4] The Canadian Institute of Health Information also raised concerns with regard to oversupply in the medical workforce, suggesting greater per capita rates of physicians and surgeons than previously recorded.

Although increasing evidence has suggested the need to assess the thoracic surgery labor market, a paucity of data has specifically addressed this issue. The objective of the present study was to address these deficits using a novel supply-demand model that uses explicit representation of the demand for thoracic surgery and the supply of thoracic surgeons at the level of the individual person and the degree of match between the 2 over time.

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Abbreviations and Acronyms

CCHS	= Canadian Community Health Survey
CT	= computed tomography
T-MED	= Canadian Thoracic Manpower and Education

METHODS

The University of Calgary Conjoint Health Research Ethic Board granted approval for the present study. A microsimulation model was used to assess thoracic surgeon supply and demand.

Supply Modeling

The model simulated the career of thoracic surgeons from training completion to retirement. The current supply of thoracic surgeons was determined using the Canadian Thoracic Manpower and Education (T-MED) survey.[5] This national survey, conducted in 2009, has provided data on the demographics, training and practice characteristics of thoracic surgeons in Canada. Using this self-reported questionnaire, detailed information on the regional and national distribution of thoracic surgeons and their age distribution and estimated retirement age were obtained. Scope of practice and resource information was also gathered, including the distribution of the clinical and academic workload, operative case load for a range of thoracic surgical procedures, and factors causing delays in the delivery of care and treatment. The number of thoracic surgeons entering the workforce was calculated according to the number of Royal College of Physicians and Surgeons accredited programs in Canada (n = 8), with a range of 4 to 8 graduates annually owing to some programs accepting only during alternate years. A typical 7-year total length of training was assumed; this included 5 years of general surgery residency followed by 2 years of thoracic surgery training. For the purposes of the present study, we assumed 0% attrition and 0% emigration probabilities once admitted into a thoracic surgical training program. Gender differences in supply were not assumed.

The model was based on 1-year cycles, with future years' projections determined from the present day supply, clinic volume, retirement estimates, and the number of thoracic surgeons entering the workforce. The model was run with a varying number of new graduates (range, 4 to 8), simulating an increasing or decreasing number of thoracic surgeons trained annually in Canada.

Demand Modeling

In the T-MED survey, the overwhelming component of clinical care for thoracic surgeons in Canada was attributed to lung cancer. Consequently, the demand model was built using lung cancer as a surrogate of the overall demand for thoracic surgeons.

Base population. Two sets of microdata were used to create the base population. The Canadian Census Public Use Microdata Files provide anonymous individual data sets with 123 variables, including income, educational status, and geographic location.[6] These individual records were then used in a combinatorial optimization population synthesis procedure[7] to replicate the entire 2006 population of Canada by age, gender, and census division per Census Metropolitan Area.[8]

The Canadian Community Health Survey (CCHS) is a cross-sectional survey that provides data on health status, healthcare determinants (eg, ethnicity), and healthcare usage. The CCHS data allow for the regional evaluation of such factors, including smoking rates.[9] These data were used to assign a smoking history (ie, current, former, never, pack years, quit time) to each member of the base population, controlling for age, gender, and location.

Dynamic models. In the microsimulation, the population is advanced using 1-year time steps, with typical demographic processes occurring and detailed models of the dynamics involved with smoking and lung cancer. The demographic components included fertility, mortality, immigration, and migration.[10-14] Mortality and infant mortality were adjusted according to gender, age, provincial differences, and non–lung cancer-related death in the smoking and nonsmoking groups both.[15,16]

The smoking models included simulations of starting and quitting smoking, with the decision to start uses a series of binary logit models estimated using the CCHS data considering age, gender, location, francophone and immigrant status, and a projected trend line (Figure 1). The quitting model considered age and gender, with smoking intensity assigned using the observed frequency data from the CCHS.[17]

The smoking status and history of each individual was a key input to the lung cancer model,[18] which considered age, smoker status (current, former, or never), smoking years, pack years, quit time, and other health factors (eg, body mass index, ethnicity, education, history of lung disease or emphysema, and chest imaging). Those with lung cancer were then assigned as early stage or late stage, according to their smoking history.[19]

The microsimulation model, using a 10% sample of the population for tractability—3.4 million people at the start of the run and increasing to 4.4 million by the end—was run from 2006 to 2039 using Python 2.7 code (Python Software Foundation, Beaverton, OR).

For the purposes of our dynamic modeling, we assumed no direct interaction between the supply and demand simulations. We assumed that the number of thoracic surgeons was not a factor influencing the incidence of lung cancer. The reverse question of whether the incidence of lung cancer would influence the number of thoracic surgeons was examined by directly varying the number of new thoracic surgeons rather than attempting to derive this factor from the interacting models.

Variability. To determine the degree of variability in the microsimulation process, 50 runs of the demand simulation and 1000 individual runs of the supply simulation were performed. The standard deviation of the mean of the projections for supply and demand was calculated.

RESULTS

Projecting Demand: Population Size and Lung Cancer Incidence

The model forecasted the population demographic change in Canada from 2011 to 2039, with totals and gender-specific and smoking status-specific estimates. During this period, the national population was projected to increase from 33 to 43 million, and the proportion of both current and former smokers was projected to decrease with time. The projected rates of the initiation of smoking according to age group with time are shown in Figure 1, with decreasing or stable rates in all groups.

The lung cancer incidence rates, as predicted by our model, are presented in Figure 2. From the model predictions, the lung cancer incidence rates will increase until 2030 and then plateau and subsequently decline. The rate of increase varied substantially by region, increasing by 12.5% in Western Canada and the Northern Territories and 37.2% in Eastern Canada. The increase was less pronounced in the 3 largest Canadian cities (10.3% in Toronto, Montreal, and Vancouver).

Projecting Supply: Thoracic Surgery Workforce

Minor fluctuations in the annual thoracic surgery graduation rates will dramatically affect the future number of