Building the Future: An integrated strategy for nursing human resources in Canada

SIMULATION ANALYSIS REPORT
Simulation Analysis Report

This report is part of an overall project entitled Building the Future: An integrated strategy for nursing human resources in Canada.

Simulation Analysis Report
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Preface

This report is part of an overall project, *Building the Future: An integrated strategy for nursing human resources in Canada*. The goal of the project is to create an informed, long-term strategy to ensure that there is an adequate supply of skilled and knowledgeable nurses to meet the evolving health care needs of all Canadians. Through surveys, interviews, literature reviews, and other research, *Building the Future* will provide the first comprehensive report on the state of nursing human resources in Canada. The project comprises the following two phases.

**Phase I:** Research about the nursing labour market in Canada is being conducted in stages. Reports will be released as the research work is completed to share interim findings and recommendations with the nursing sector. A final report will be produced at the conclusion of this phase that will include all of the recommendations accepted by the Nursing Sector Study Corporation.

**Phase II:** A national strategy will be developed in consultation with government and non-government stakeholders that builds on the findings and recommendations presented at the completion of Phase I.

To oversee such a complex project, the Nursing Sector Study Corporation (NSSC) was created in 2001. The Management Committee of NSSC comprises representatives of the signatories to the contribution agreement with the Government of Canada and other government groups.

The multi-stakeholder Steering Committee for the project comprises approximately 30 representatives from the three regulated nursing occupations (licensed practical nurse, registered psychiatric nurse, and registered nurse), private and public employers, unions, educators, health researchers, and federal, provincial and territorial governments. The Steering Committee guides the study components and approves study deliverables including all reports and recommendations.

Members of the Management Committee and the Steering Committee represent the following organizations and sectors.

- Aboriginal Nurses Association of Canada
- Association of Canadian Community Colleges
- Canadian Alliance of Community Health Centre Associations
- Canadian Association for Community Care
- Canadian Association of Schools of Nursing
- Canadian Federation of Nurses Unions
- Canadian Healthcare Association
- Canadian Homecare Association
- Canadian Institute for Health Information
- Canadian Nurses Association
- Canadian Practical Nurses Association
- Canadian Union of Public Employees
- Health Canada
- Human Resources and Skills Development Canada
- National Union of Public and General Employees
- Nurse educators from various institutions
- Ordre des infirmières et infirmiers auxiliaires du Québec
- Ordre des infirmières et infirmiers du Québec
- Professional Institute of the Public Service of Canada
- Registered Psychiatric Nurses of Canada
- Representatives of provincial and territorial governments
- Service Employees International Union
- Task Force Two: A human resource strategy for physicians in Canada
- Victorian Order of Nurses Canada

Together, we are committed to building a better future for all nurses in Canada and a better health system for all Canadians.
Executive Summary

The supply of nurses in Canada, as well as in other countries, has been characterized by cyclical patterns of shortage and surplus. In the early 1990s, most provinces and territories were experiencing an oversupply of nurses. A decade later, Canada is facing a growing nursing shortage that has become a primary concern for governments, educational institutions, and other health care planners.

This report is intended to complement the Canadian Nursing Labour Market Synthesis and is part of the overall research for Building the Future. The focus in this report is on the supply of nurses. This report focuses on an empirical analysis and simulation of demographic scenarios affecting the future supply of nurses in the three regulated nursing professions: registered nurses (RNs), licensed/registered practical nurses (LPNs), and registered psychiatric nurses (RPNs).

Methods

Previous modelling efforts in Canada have focused on forecasting future supply for planning purposes. In contrast, the goal of this analysis was to better understand the relative impact of various factors affecting future supply in both the short and long-term. By doing so, it provided valuable insights on the reasons for the current crisis and provides insights on alternative options for addressing it.

The study employed new empirical data on age distributions and the rates of recruitment and retention for the LPN, RN and RPN workforce. This is the first study to employ such data for LPNs and RPNs, and the first to examine this data for RNs of all ages. Previous efforts to model future supply of nurses have, for the most part, not been able to use empirical data on rates of recruitment and retention. Instead, assumed values have been used. Data on registrations for the three regulated nursing professions, assembled by the Canadian Institute for Health Information (CIHI) into national databases, were used to examine age distributions of nurses by province/territory and sector of employment, and to measure recruitment and retention rates.

A simulation model was developed to explore the short and long term impact of differences in age distributions and recruitment and retention rates on future supply. General simulations were used to analyze (a) the relative impact of an aging workforce and rates of recruitment and retention on future workforce size and age distribution, (b) the effect of increasing the number of training seats on supply under different recruitment and retention scenarios, and (c) short versus long-term effects of changes in the age of retirement. Simulations by province and nursing group were used to examine the effect of alternative retirement scenarios on supply within the next five to 10 years, and to produce new indicators that show what the long-term consequences would be of current patterns of recruitment and retention.

Findings

Because of aging of the nursing workforce, declines in workforce size in the next ten to twenty years are almost certain. All three regulated nursing professions have workforces with a high proportion of nurses concentrated in the older age groups. The result is a “demographic time bomb” that will result in a large portion of the current workforce retiring in the near future. Even if lots of new nurses are trained, it will be very difficult to offset the large number of retirements that will be occurring.
How was this demographic time bomb created? It is a reflection of the unique labour market experiences of nurses over the last 30 to 40 years, and cannot be explained by events in the last two decades alone. The high degree of concentration of the workforce in the older age groups is due to large differences in the educational opportunities and labour market experiences of different cohorts of nurses (i.e. nurses trained at about the same time). There have been dramatic changes in nursing school enrollments and seats during times of bust and boom. The varied experiences also reflect periods of growth and decline in the number of nursing positions, variations in workforce retention associated with alternative career opportunities, and layoffs associated with downsizing of the acute care sector (which had the most dramatic effects on younger nurses).

The simulations clearly show that, regardless of future scenarios, it is unlikely that future age distributions will look anything like the current age distribution. Unless we continue to have shifts in policies and funding for the health care system that create large differences in the labour market experiences of nursing cohorts, future age distributions will be younger and be less concentrated around certain ages. In other words, the crisis we are now facing is unique, and not a long-term reality of the nursing workforce.

The results of this study show that we need immediate strategies to help us “weather” the current crisis, without creating the conditions for similar crises in the future. For example, diffusing the current demographic time bomb by focusing solely on recruitment and training may create a new bomb with a 40-year fuse. It would require creating a new large cohort of younger nurses to offset the large cohort retiring, and thus set the stage for a similar demographic crisis in about 40 years.

The simulations demonstrated that the effect of increasing the number of training seats on the future size of the workforce depends on the level of retention of nurses in the workforce. Low rates of retention of nurses in the workforce can dramatically erode the gains in supply from increasing the number of training seats. Thus, to be cost-effective, increasing the number of nurses being trained must be combined with effective methods of retaining trained nurses in the workforce.

In the long-term, the simulations suggest that the impact of changes in the retirement age on the workforce supply may be quite small, but they also showed that changes in the age of retirement could be a valuable short-term strategy for coping with the current crisis. Reducing the rate of early retirement can substantially alter the timing and speed of decreases in the workforce resulting from the “demographic time bomb.”

The ability to address shortages in a nursing group or other health care providers by increasing the scope of practice of nurses is constrained by supply. There is unlikely to be surplus in any of the three professional nursing groups. Augmenting requirements for one nursing group with another or augmenting requirements for other health professions with nurses is unlikely to be feasible.
Recommendations

1. In developing strategies to cope with continuing shortages of nurses, planning must consider both short and long-term implications of policies on nursing supply. We can no longer rely on short-term fixes to deal with immediate shortages, especially if they may have negative long-term implications. This is necessary to avoid creating future crises such as the one we are now experiencing.

2. Policy makers need longer-term policies, based on good planning, that create the conditions for a more uniform age distribution that does not result in future cyclical shifts in supply. This can be accomplished by:
   
   a. Including the monitoring of age distributions in human resource planning to ensure that the workforce is not heavily concentrated around certain age groups, and that the workforce has a healthy mix of nurses with different levels of experience.
   
   b. Developing policies that help ensure the stability of labour market experiences across nurses entering the workforce at different times.
   
   c. Incorporating new indicators of long-term supply outcomes in human resource planning that show the direction implied by current policies, recruitment rates and retention rates. We have proposed two such indicators.
   
   d. Conducting ongoing simulations and forecasts, repeated at least every five years.

3. Increasing the number of training seats must be combined with policies to improve retention of nurses in the workforce. The cost-effectiveness of any policy for increased training and recruitment depends on retention. Poor retention of nurses in the workforce can easily erode the gains made by increased training and recruitment.

4. In the short-term, policy makers should consider policies to reduce the frequency of early retirement as a means of “buying time” for coping with declines in workforce size. However, the long-term effect of this strategy must be carefully evaluated. Slowing workforce decline for five to 10 years by delaying retirement can result in a more rapid decline in workforce size following the delay.

5. Ongoing investment in databases for health human resources planning that are of good quality and comparable is critical. Limitations in the quality and number of years of data available hampered the ability of this study to effectively model LPNs and RPNs. As additional years of CIHI data on LPNs and RPNs become available, these barriers will be broken down.
1. Introduction

The supply of nurses in Canada, as well as in other countries, has been characterized by cyclical patterns of shortage and surplus. In the early 1990s, most provinces and territories were experiencing an oversupply of nurses (Dussault et al., 1999). Health care system restructuring, especially in the acute care sector, resulted in large-scale layoffs, and labour market opportunities for new nursing graduates in Canada deteriorated. Decreases in training seats resulting from cuts in public sector spending and predictions that health sector restructuring would reduce the demand for nurses led to large reductions in the number of nurses trained. Admissions to education programs for RNs declined by 35% in the 1990s, and many nurses sought work in other countries or professions (Dussault et al., 1999).

A decade later, Canada is facing a growing nursing shortage, and the shortage of nurses has become a primary concern for governments, educational institutions, and other health care planners (Ryten, 1997; Ryten, 2002; CNAC, 2000; Ministry of Health and Ministry Responsible for Seniors of BC, 2000). The shortage of nurses has been attributed to a variety of factors. According to the final report of the Canadian Nursing Advisory Committee (CNAC, 2002), the primary factors causing the shortage include management issues that hinder nurse productivity, and insufficient funding to hire nurses. Increases in patient acuity, growing complexity of care environments, and increasing workloads have further reduced the morale and work satisfaction of nurses, which has exacerbated the shortage (CNAC, 2000). However, it would be short-sighted to fully attribute the current crisis to the events of the 1990s. Ryten (2002) noted that the current shortage of RNs in Canada is also the result of age distribution, established well in advance of the 1990s, which would inevitably result in a large increase in the number of retirements.

The cyclical pattern of surplus and shortage currently being experienced in nursing is not unique (Duffield & O’Brien-Pallas, 2002). Such patterns have been experienced in many professions, and have been a recurring theme of human resource planning. It is important to consider some critical questions such as: Why do such patterns occur? Why has health human resource planning failed to recognize and respond with strategies and planning mechanisms to prevent these problems? Of course, competing interests, political factors, and failure to plan based on evidence may be contributing reasons to the recurring shortages. However, these challenges are also a reflection of inadequate financial and human resources being devoted to health human resource planning. Efforts to carry out human resource planning for nurses and other health professions have been characterized as intermittent, of variable quality, and constrained by insufficient data (O’Brien-Pallas, Birch et al., 2000). Forecasting has also been plagued by faulty assumptions, failure to incorporate adequate complexity, and the inability to anticipate changes that alter the system (O’Brien-Pallas, Birch et al., 2001; Tomblin Murphy, 2002; Birch, et al., 2003).

Indeed, all forecasts and simulations are based on numerous assumptions and the uncertainty of the results increases as they are extended into the future. Forecasting future health human resource requirements for long-term planning is a challenge. The main objective of modeling efforts should be to identify future scenarios, identify the factors which will influence the scenarios such as political, social, geographical, technological ones. By so doing, the results of the modeling techniques will enhance the ability of policy makers to anticipate and plan for human resources in a more meaningful way.
This report focuses on an empirical analysis and simulation of demographic scenarios affecting the future supply of nurses in the three regulated nursing professions: RNs, LPNs, and RPNs. The report is intended to complement the Canadian Nursing Labour Market Synthesis and is part of the overall research for Building the Future. The focus in this report is on the supply of nurses. It is important to note that supply is only one component of the broader health human resource planning framework guiding the larger project (O’Brien-Pallas, Birch et al., 2001; O’Brien-Pallas, 2002). This simulation does not attempt to incorporate estimates of the future population health need or the demand for nursing services, nor does it directly model the impact of work environment factors. However, it does provide an important foundation for future simulation models that can incorporate these factors. In fact, the results of this simulation define the potential range of impact of other factors in the broader framework, and guide priorities for future modelling efforts.

The study employed new empirical data on the rates of entry and exits (i.e., rates of recruitment and retention) from the nursing workforce, and is the first to employ such data for LPNs and RPNs. Previous efforts to model future supply of nurses have, for the most part, not been successful in incorporating empirical data on rates of entry and exit from the workforce. O’Brien-Pallas, Alksnis et al. (2003a, 2003b) used a cohort projection model to estimate retirement rates by age from sequential years of the Canadian Institute for Health Information (CIHI) Registered Nurse Database (RNDB), and model their impact on supply. In this study, we extended this method to a broad age range (25 to 65) of registered nurses. In addition, we were able to access preliminary 2003 data from the CIHI LPN and RPN databases (LPNDB and RPNDDB), and combined them with the 2002 LPNDB and RPNDDB data (the first year available) to apply this method to LPNs and RPNs. Analysis of the rates of entry and exit from nursing are critical for planning purposes, and thus an important contribution of this study. While data on the numbers and ages of nurses has been available from various sources for some time, data on the rates of recruitment (entry into the workforce) and retention (rates of exit from the workforce) have not been available. These are critical variables determining the future supply of nurses.

This study employed a system dynamics simulation approach (Song & Rathwell, 1994; O’Brien-Pallas, Baumann, Donner, et al., 2001; Tomblin Murphy & O’Brien-Pallas, 2002; Tomblin Murphy & O’Brien-Pallas, 2003; Richardson, 1991; Sterman, 2000; Wolstenholme, 1990; Forrester, 1968). The primary value in this simulation approach is its ability to integrate knowledge of different components of the system, improve understanding of the dynamics of the system, and enable the rehearsal of strategies and policies to avoid hidden pitfalls. While previous modeling efforts in Canada have focused on forecasting future supply, as well as demand, their goal has been to predict future requirements (Ryten, 1997; Ryten, 2002). In contrast, the goal of this analysis is to better understand the relative impact and dynamics of various factors affecting future supply from both a short and a long-term perspective. In doing so, it provides valuable insights on the reasons for the current crisis and permits the modeling of alternative options for addressing it.

The remainder of this report consists of four sections. Section 2 describes the methodology used, including the simulation model, data sources, measurement and estimation of key variables, and the methods of analysis. The associated strengths and limitations of the data and methods are discussed.
Section 3 provides a descriptive analysis of the age distributions and combined entry/exit rates estimated from the CIHI RN, LPN, RPN databases. Since they are the key factors determining the future size of the nursing workforce, describing variations in age distributions and combined entry/exit rates by province (and over time for RNs) provides an empirical basis for future projections. Clearly, entry and exit rates in the future are unlikely to remain at current levels, and cannot be reliably predicted from past trends. However, variation over time and by provinces and territories helps to define the range of future variations. Also, for planning purposes current rates provide a baseline against which targets for future rates can be assessed.

Section 4 describes the results of general simulation analysis that examine the general properties of nursing populations. In this section the relative impact of initial age distribution and entry/exit rates at different ages is assessed. The simulations adopt both a short and a long-term time horizon. By long-term, we mean a period of 45 years, which covers the full working career of a cohort of nurses. Simulations of this duration are necessary to uncover model dynamics that cannot be seen in short-term simulations. This long-term approach is used to understand the effect of variation in input parameters over time on the future number and age distribution of nurses. The purpose of the long time horizon is not to predict what the supply will be in future years. Rather, the purpose is to understand how different factors, such as age structure, and recruitment and retention rates of nurses in the workforce, interact to affect supply in the long-term. Understanding the dynamic way in which these factors interact to affect supply in the long-term is critical to understanding how to plan in the short-term. Ultimately, actual future changes in supply will depend on actual changes in recruitment and retention rates that are difficult to anticipate more than a few years into the future. Thus, long-term forecasts are unreliable. Nevertheless, policies must be evaluated in terms of both short-term and long-term implications. Human resource planning and policies are important determinants of future supply, and need to be guided by a thorough understanding of their long-term implications. We cannot continue to focus on short-term fixes alone. The results from this report will demonstrate that there are critical lessons to be learned from this type of simulation.

Section 5 applies the simulation models to specific nursing groups in specific provinces. Here, we estimate and demonstrate the use of two useful planning indicators that we developed from the general simulations. These indicators provide a means of assessing the long-term implications of current labour market policies and conditions. They can be used along with short-term forecasts to balance short and long-term goals in health human resource planning. In this section, we also update and extend previous work, conducted by the research team, which examined the short-term losses from the workforce that would result from different retirement scenarios (O'Brien-Pallas, Alksnis et al., 2003a, 2003b). Simulations were run to estimate changes in the workforce over the next ten years under alternative age-of-retirement scenarios.

In section 6, we present the major conclusions and recommendations that arise from this study. We discuss the origins of the current nursing shortage, what was learned from the simulations to help cope with the shortage in the short-term and what can be done in the long-term to prevent future cycles of surplus and shortage.
2. Methods

2.1. Overview

This study employs data and methods that were originally developed for the purpose of projecting Ontario’s nursing supply and for projecting RN retirement in Canada (O’Brien-Pallas, Alksnis et al., 2003a, 2003b). This study extends the methodology to data for all provinces and territories, and to nurses age 25-65, including RNs, LPNs, and RPNs.

Data on registrations for the three regulated nursing professions, assembled by the CIHI into national databases, were used to examine age distributions of nurses by province/territory and sector of employment, and to estimate the net gain or loss in the numbers of nurses between sequential years of registry data. The net gain or loss in the number of nurses reflects the difference in the number of additional nurses added, as a result of entry into the profession or entry into work, minus the number of nurses lost due to leaving the profession or leaving work (due to factors such as emigration, retirement, death or long-term disability). Together, the age distribution and net rates of gain or loss in the number of nurses (i.e., rates of recruitment and retention) provides the basis for projecting the supply of working nurses.

Initially the age distributions and net rates of gain or loss in the number of nurses were examined to understand how these variables vary across time and among provinces and territories. Understanding the variability of these rates over time and their variation across provinces provides a basis for gauging the potential variation of these variables in future years. Furthermore, it assists in understanding the demographic factors contributing to the current demographic situation in the provinces and territories.

Drawing upon the observed variation in key parameters affecting the supply of nurses, a simulation model was developed to explore the dynamics affecting the future supply of nurses. The simulations explored the short and long term implications of differences in age distributions and net rates of gain or loss in the number of nurses on future supply.

2.2. Data Sources

This study used data from three CIHI data sources including the Registered Nurses Database (RNDB), the Licensed Practical Nurse Database (LPNDB), and the Registered Psychiatric Nurse Database (RPNDB) (CIHI, 2002a; CIHI, 2002b, CIHI, 2002c). Data from all provinces and territories were employed for all available years. A long time series of data (1993-2003) was only available from the RNDB. For the LPNDB and the RPNDB, only two years of data are available (2002 and 2003). The 2003 numbers employed from all three databases were obtained prior to official release by CIHI (expected in November, 2004), and are thus still considered preliminary. However, any additional changes to the CIHI numbers prior to release are expected to be relatively small. The extraction and reporting of all data in this study are consistent with CIHI privacy policies, designed to protect data maintained by the organization.

For each of the three CIHI databases used, the provincial registration data was subjected to a series of editing processes to improve the accuracy and to remove duplicate records. For example,
nurses can be registered in more than one province or territory, or be registered in Canada and work abroad. CIHI employs a methodology to flag and exclude nurses working abroad, and duplicates arising from registration in multiple provinces (CIHI, 2002a). The methodology employed by CIHI to remove duplicate registrations can have a major impact on the northern territories because of the substantial number of short-term relief staff. Many staff employed in the northern territories hold primary registration in another province. Accordingly, in 2001 CIHI changed their methodology so that inter-provincial duplicates were included. This will result in an apparent increase in the number of registered nurses between 2000 and 2001 in the territories, as well as for Canada as a whole. However, because nurses in the territories comprise only a small percent of all nurses, the impact on national Figures will be minimal. Accordingly, separate estimates of estimated entry/exit rates in the territories between the years 2000 and 2001 were not included in the analysis.

2.3. Study Population

The target population for this study was nurses (RNs, LPNs, and RPNS) in the workforce. The CIHI databases include information on all nurses submitting active-practicing registration in the first six months of their jurisdictional registration year. Thus, the CIHI data included nurses who are not working. For the analyses in this report, the population in these databases was further restricted to nurses age 20-65 who were employed in nursing at the time of registration. It is important to note that the unit of analysis is employed nurses, not nursing hours per patient day or number of full-time equivalents. Self-reported working hours are no longer collected by CIHI for inclusion in their databases because the data are considered to be of poor reliability. Due to small numbers, special handling of the population under age 25 was required to protect confidentiality. This is discussed in more detail below.

A limitation of defining the study population as employed nurses is that nurses who do not state whether their employment is full-time, part-time or casual on their registration have missing data, and thus their employment status is not known. These nurses were not included in the study population, and thus were treated as not employed in nursing. This limitation had important and unexpected consequences for the analysis. Unemployed nurses are not included in our study population. As a result year-to-year fluctuations in the frequency of missing data affected the estimates of annual net growth or loss in the number of nurses. This problem was not substantial in our previous work using the methodology (O'Brien-Pallas, Alksnis et al., 2003a, 2003b). However, the missing data has emerged as a greater problem for the 2003 registered nurse data in Ontario and Quebec and 2003 LPN data in all jurisdictions. In 2003, there was a large jump in the number of RNs in Ontario with missing data on their employment status. Accordingly, a revised methodology was developed by CIHI and data providers in Ontario and Quebec for their 2002/03 data to include nurses who had an employer, but who failed to respond to the employment status question. The result is a substantial increase in the apparent number of employed RNs and LPNs between

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1 The timing of the registration year varies between provinces and territories. CIHI to help standardize the consistency of reporting times between provinces, while minimizing undercounting due to missed registrations. CIHI estimates that the percent of missed registrations to be approximately 3% - 5%.
2002 and 2003 in both Ontario and Quebec. Moreover, there was a substantial decline in the number of records with missing employment information across a number of other provinces in the LPN data between 2002 and 2003. From the perspective of the RNDB and LPNDNB, this is good because the 2003 data is more accurate; however, for our analysis this results in an apparent growth in the number of employed RNs and LPNs between 2002 and 2003 that is artificially high. There was no way for us to adjust numbers to address this problem. Accordingly, we did not employ 2002-2003 estimates of net growth in the number for registered nurses, and did not run simulations for LPNs because of these problems. The degree to which similar problems affect the RPN data is not known; although, the data do not suggest that problems exist.

2.4. Measurement and Analysis

2.4.1. Age Distributions

Age distributions of nurses were estimated separately for the three regulated nursing professions, and examined by province and employment sector. Employment sector was broken down and classified as acute care and other. Acute care includes hospitals, mental health centres, and nursing stations. The Non-Acute category includes all other sectors including rehabilitation/convalescent centres, long-term care facilities, community care (community health care and home care) and sectors that CIHI classifies as other. Because of small cell sizes, more detailed breakdowns by employment sector were not feasible.

To further adjust for sample variability in age distribution, and to facilitate provincial comparisons, age was collapsed into three-year age groups, and numbers were expressed as percentages of the total population size. Graphs were used to show variation in age distributions by nursing group, employment sector and province.

2.4.2. Growth Rates in the Population of Nurses by Age

Entry and exit rates (i.e., recruitment and retention rates) from the workforce cannot be directly computed from our data. However, a combined rate can be computed, which we call the “annual net growth rate.” Computations of annual net rates of growth (or loss) are based on the change in the number of nurses for single-year cohorts between sequential years of registration data. A cohort refers to nurses who are the same age in a given year. The net growth for a cohort is computed as the change in the number of nurses in a single year age cohort over a year. It is equivalent to the difference between the number of new nurses who entered the age cohort between two registration years, and the number who left the cohort between two registration years. The net growth is then divided by the initial number of nurses in the cohort to obtain an estimate of the annual net growth rate.\(^2\)

\[ G_x = \left( \frac{P_{x+1,y+1} - P_{x,y}}{P_{x,y}} \right) \times 100 \]

where \( G_x \) is the annual net growth rate, expressed as a percentage, \( P_{x,y} \) is the number of nurses in age group \( x \) in year \( y \), and \( P_{x+1,y+1} \) is the number of nurses in age group \( x+1 \) in year \( y+1 \). If there is a net decline in the number of nurses in an age group, the estimated annual net growth rate will be negative. However, it will still be referred to as a growth rate in this report, and will represent negative growth (i.e., loss).

\(^2\) This is expressed by the formula: \( G_x = (P_{x+1,y+1} - P_{x,y}) / P_{x,y} \times 100 \). \( G_x \) is the annual net growth rate, expressed as a percentage, \( P_{x,y} \) is the number of nurses in age group \( x \) in year \( y \), and \( P_{x+1,y+1} \) is the number of nurses in age group \( x+1 \) in year \( y+1 \). If there is a net decline in the number of nurses in an age group, the estimated annual net growth rate will be negative. However, it will still be referred to as a growth rate in this report, and will represent negative growth (i.e., loss).
The reliability of the estimated annual net growth rates is poor if the denominator of the rate calculation (i.e., the number of nurses age $x$ in year $y$) is small. When this number is small, the rate fluctuates considerably across ages and years. This problem occurs most frequently in smaller provinces and the northern territories, particularly when the population is broken down by employment sector. It is also a problem for RPNs because they have much smaller numbers than the other two nursing groups. Accordingly, steps were taken to ensure that random fluctuations in the rates did not unduly affect data interpretation and the simulation models. More specifically:

- Estimation of annual net growth rates was limited to nurses age 25 to 64. While some nurses continue employment past age 65, our estimates and the simulations assumed that all nurses retired at age 65. For ages under 25, annual net growth rates were not computed. However, data on the number of nurses under age 25 by year were extracted from the CIHI data, and the simulation models entered a fixed number of new 25 year olds each year.

- The northern territories were grouped together prior to extraction of the CIHI data. Nevertheless, estimated annual net growth rates for the territories did not have large enough denominators to produce reliable estimates, and the decision was made to not report estimated annual net growth rates for the northern territories. However, data from the territories were included in Canadian estimates.

- Prince Edward Island also had highly variable estimates, and is thus not reported in a few analyses. However, it was included where possible.

- For registered nurses, where annual net rates of growth rates for multiple pairs of years could be calculated, estimates were averaged over four years (1999-2000, 2000-2001, and 2001-2002). This was not possible for LPNs and RPNs as only two years of data were available, and thus rates for these professions are less reliable.

- Prior to using estimated annual net growth rates in simulation models, rates were smoothed across ages using statistical regression methods. Age was first broken down into three groups for which the age trend in rates was approximately linear: 25-30, 31-54, 55-65. Linear regression was then used to describe the growth rates as a function of age and province, and an age by province interaction term was used in the model. Predicted values from these models were employed in the simulations.

## 2.4.3 Simulation Analyses

This study employed a system dynamics simulation approach (Song & Rathwell, 1994; O’Brien-Pallas, Baumann, Donner, et al., 2001; Tomblin-Murphy & O’Brien-Pallas, 2002, Tomblin-Murphy & O’Brien-Pallas, 2003; Richardson, 1991; Sterman, 2000; Wolstenholme, 1990; Forester, 1968). The primary value in this approach is not forecasting per se. Its principle value rests in exploring system dynamics. It is a powerful tool for integrating knowledge of different components of complex systems, improving understanding of the dynamics of the system, and rehearsing strategies and policies to avoid hidden pitfalls.
While previous modeling efforts in Canada have focused on forecasting future supply, as well as demand, their goal has been to predict future requirements (Ryten, 1997; Ryten, 2002). In contrast, the goal of the simulation analysis is to understand the relative impact and dynamics of various factors affecting future supply. Illustrative examples of these types of models can be found in fields such as demography and population biology, where models of the dynamics of populations have been developed that express and model the mathematical relationships between key determinants of population supply: the age distribution of the population, birth rates, death rates and the growth rates of the population. More complex models explore the inter-relationship between regions, or between two populations (e.g., coyotes and rabbits). These models have shown that populations are characterized by complex, yet formal and stable relationships between variables (Keyfitz, 1978). Moreover, modeling and simulating these relationships has provided many practical insights useful for planning. They have provided a basis for more accurate projections and forecasts for short-term predictions. At the same time, they have provided simulations and models that enable analysis of the longer-term implications of alternative policies. Applied to human resource planning for nursing, we believe that dynamic simulation models can provide valuable insights on the reasons for the current crisis, and permit the modeling of alternative options for addressing it.

Application of demographic models illustrates the value of this approach, and shows the importance of modeling both short and long-term outcomes. The use of long-term modeling to evaluate population policy in China is a useful example (Sun, 1998; Bongaartz & Greenhalgh, 1985). In the 1970's China had one of the fastest growing populations, and was deeply concerned about over-population. In response, China instituted a strongly enforced “one-child” policy in the late 1970s to stem rapid population growth. The policy has been somewhat relaxed since, but China still maintains very aggressive birth control policies to curb population growth. The programs have been highly successful. China's birth rate has declined dramatically since the 1970s and has been in the range of replacement fertility (i.e., each couple on average only has about two children) for more than 10 years (US Census Bureau, 2002). However, the young population age distribution of China, which was the result of many decades of rapid population growth, means the population still continues to grow. China is still growing by about 10 million people per year, and is projected to grow to nearly 1.4 billion before peaking in about 2030 (US Census Bureau, 2002). The degree to which the policy should be maintained or relaxed is a subject of considerable debate. For example, Sun (1998) and Bongaartz and Greenhalgh (1985) have modeled the effect of alternative family planning policies in China. In addition to evaluating the effect of policy alternatives on future population size, both studies showed that different policy alternatives would have large effects on the rate and extent of aging of the population. This has profound implications for planning education, health and old age retirement programs. While these models do not serve as reliable forecasts of the future population of China, they have been effective in guiding China's policies. Why? They are effective because they showed what the long-term implications would be of alternative family planning policies.

Effective use of simulation models requires a team of people with varying perspectives to interpret the findings and to develop the policy messages from the findings. Researchers, planners and others need to work together, and this study is an example of a team approach. We have nurses, demographers, health economists, etc. interpreting this work.
2.4.3.a. Description of simulation model

The simulation model was implemented using the program Vensim (2002). Vensim is a modeling tool that allows planners to conceptualize, build, and run dynamic simulation models. It is based on an underlying mathematical model that expresses levels (e.g., the number of nurses) as a function of a series of rates that change levels over time (e.g., retirement rates) and other variables that determine the values of those rates (e.g., retirement policies). These are expressed as a series of mathematical equations that are then solved to run the simulation. Vensim was selected because of its programming flexibility, ability to handle complexity, its graphical interface, and its extendibility. The team desired a tool that could be extended in the future to incorporate additional system components such as productivity, work environment and population health needs. Graphical tools provide an excellent communication tool, thus enhancing the ability to communicate model results, and support the engagement of multiple disciplines and policy makers in the simulation process.

The supply-based model used in this report is based upon a method developed by the Health Human Resources modeling group working under the Nursing Effectiveness, Utilization and Outcomes Research Unit at the University of Toronto (O'Brien-Pallas, Alksnis et al., 2003a, 2003b). The method is based on projecting the population of employed nurses forward in time based on an initial age distribution, and estimates of annual net rates of growth (or loss) in the number of nurses by single years of age.

Figure 1. Diagram of the Dynamic Simulation Model
The simulation model developed and used for this analysis is shown in Figure 1. In this diagram, the box “Nurses” is a level describing the population of nurses in one of the three nursing groups (separate simulations were run for each). In the program, the population is broken down into single-year age groups. With each year of program iteration, the population is aged by one year. The population of nurses modified over time by the rate variables, which are shown in the diagram as an hourglass. Two rate variables are shown: the “entry” rate and the “annual net growth rate”. Like the nurse population variable, the annual net growth rate variable is also broken down by age, and its initial values were based on analysis of the CIHI data. In the simulation, the age pattern of net growth rates was altered over time according to different assumptions, or as a result of other system variables. The rate variable “entry” denotes the addition of new nurses into the youngest age (age 25). However, the entry of nurses from education programs was also implicitly captured in the annual net growth rates for ages above 25. These rates were generally positive until age 30 to 35.

Empirical analysis of the CIHI data on age distributions and annual net growth rates by age were used to guide data inputs into the simulation model. However, it was not assumed that present values of these variables would hold into the future. The values of input variables were altered to explore the dynamics of the model. For example, based on analysis of the range of age distributions across provinces and territories, two age distributions were selected to explore the impact of age distribution on future supply. We included a “young” age distribution, which approximates the actual age distribution of registered nurses in Newfoundland and Labrador, and an “old” age distribution that approximates the age distribution of registered nurses in British Columbia. Similarly, we varied the age pattern of annual net growth rates based on the experiences of different provinces and nursing professions. By using actual data to guide the simulations, the ability to generalize the results is enhanced.

The simulation analysis proceeded in two stages. In the first stage the general dynamics of the model was explored. During the second stage the simulation analysis was applied to specific provinces and professional groups. Specifically, the simulations were used to examine the effect of alternative retirement scenarios on supply within the next five to 10 years, and to produce indicators that show what the long-term consequences would be of current patterns of recruitment and retention. Results from the general simulation analyses are presented in section 4, while simulation analyses by province and professional group are presented in section 5.

2.4.3.b. General Simulation Analyses

In the first stage of simulation analyses, the relative impact of combinations of young versus old age distributions and low versus high age patterns of annual net growth rates were examined. Subsequent simulations explored the short and long-term impacts of increasing the number of nurses trained and changes in the age of retirement. Each of these simulations explored short and long-term outcomes.

2.4.3.c. Simulations by Province and Professional Group

In the second stage of the simulation analyses, models were run by nursing group and province for two purposes. First, simulations were run employing current estimates of annual net growth rates to demonstrate two new indicators for health human resource planning that we derived from the general
Simulations. These indicators show the long-term size of the workforce and the age distribution that is implied by current rates of recruitment and retention of nurses in the workforce. We refer to them as the “implicit workforce size” and the “implicit age distribution.” They are not intended to be predictions; rather, they are intended to show what the long-term implications would be of current education levels and labour market experiences of nursing groups. They show where we are headed if we do not change course, and indicate the magnitude of course changes that will be required. Second, simulations were run to update and extend previous work on retirement scenarios that has been conducted by the research team (O’Brien-Pallas, Alksnis et al., 2003a, 2003b). The simulations show the impact of changes in the age of retirement on the size of the nursing workforce over the next 10 years.

Because of concerns about data accuracy and unreliability of estimates required for the simulations, some exclusions were necessary. Simulations were not run for LPNs. As discussed above, estimates of annual net growth rates for LPNs were implausibly high due to changes in the coding of the employment status variable in the LPNDB. Simulations were also not run for the north because high sampling variability in the annual net growth rates, due to small numbers, make the results unreliable. Simulations were run and presented for Prince Edward Island, and for RPNs, but should be interpreted with caution since estimates of annual net growth rates also have high sampling variability.

**Indicators of implicit workforce size and age distribution**

From the general simulations, it was learned that any population of nurses, regardless of their initial age distribution, would converge to a constant workforce size with a constant age distribution in 35-45 years. We will refer to these as the “implicit workforce size” and the “implicit age distribution.” For example, two nursing populations with very different initial age distributions would, if they were subject to stable and similar labour market experiences converge to about the same size and age structure. In the short-term, the differences in their age distributions would result in different trends in population size, but the trends would converge in 35-45 years to a constant population size, and they would have identical age distributions. The “implicit workforce size” and “implicit age distribution” are useful indicators for health human resource planning.

We used the simulations to generate estimates of the implicit workforce size and age distribution by province and nursing group. They show the long-term size and age distribution of the workforce implied by current estimates of annual net growth rates (i.e. current rates of recruitment and retention). For comparison, implicit workforce size was tabulated along with the current workforce size used in the simulations. The current workforce size is defined here as the number of employed nurses aged 25-65. This will be less than the number of nurses in a province with active registrations, and slightly less than estimates of the number of employed nurses in the CIHI datasets since nurses under age 25 and over age 65 were not included. Implicit workforce sizes and age distributions were generated by running the simulations for each province and nursing group until they converged to a stable size and age distribution. All simulations converged by 45 years. In each province and nursing group, the simulations used age-specific annual net growth rates fixed at their current estimated values, current workforce size, and initial age distribution. For registered nurses, smoothed values of the average of annual net growth rates for the
three years of data (2000 to 2002) were used (see description of regression smoothing above). For RPNs, only annual net growth rates for 2002-2003 were available, so averaging over years was not possible. However, regression smoothing was used to reduce random variation across ages. Nevertheless, sampling variability due to small numbers means that indicators for RPNs should be interpreted with caution.

As discussed above in section 2.3, estimates of annual net growth rates for LPNs were implausibly large in most provinces, and when applied in simulations, generate implausibly large growth for future years. We believe that this is a result of accuracy and coding issues with the employment status variables used to select employed LPNs. Accordingly, indicators of implicit workforce size and age distribution were not considered suitably reliable to be reported.

**Retirement scenarios**

Simulations were run to update and extend previous work by the research team on the effect of early retirement on the size of the nursing workforce over the next 10 years (O’Brien-Pallas, Alksnis et al., 2003a, 2003b). In the general simulations, the long-term effects of changes to the age of retirement were explored. The purpose of these simulations was to estimate short-term changes in the size of the nursing workforce under different retirement scenarios. For each province and nursing group, three retirement scenarios were run.

1. The first scenario estimated changes in the size of the workforce assuming that current annual net rates of growth for ages 55-64 were maintained. In other words, it was assumed that the current pattern of nurses leaving the profession due to retirement, death and disability did not change.

2. The second scenario simulated a worst-case scenario, i.e. full retirement at the age of 55. To simulate full retirement at age 55 annual net growth rates were held constant at the average levels for each nursing group and province up to the age of 54, and then had all nurses retire when they turned 55.

3. The third scenario simulated a best-case scenario (i.e., no early retirement, i.e., full retirement at age 65). To simulate full retirement at age 65, the net annual growth rate was set to the average levels for each nursing group and province up to age 54, -1% per year from age 55 to 64, and to -100% at age 65. In other words, we assumed that we lost 1% of the nurses in each age group each year due to death and disability, and then all that remained retired at age 65. A net annual growth rate of -1% was used to account for losses that would be due to death and other factors such as disability. Essentially this means that we assumed that even in a best-case retention scenario approximately 1 nurse out of every 100 at each age would leave the profession because of death, illness or injury.³

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³ We considered using mortality rates from vital statistics data. However, mortality data are not specific to nurses (who may have higher or lower mortality rates than Canadian women), and would not include losses due to other factors such as disability.
Some differences in methodology between the previous work by the team and the results presented here should be noted:

- O’Brien-Pallas, Alksnis et al. (2003a, 2003b) used the average annual net growth rates for the years 1997/98 to 2000/01.

- In these analyses, smoothed average annual net growth rates for the years 1999/2000 to 2001/2002 were used.

- In the full retirement at age 65 scenario, we assumed net loss due to other causes to be -1% per year between ages 55 and 64, while O'Brien-Pallas et al. used estimates of single-year female mortality rates obtained from 2001 vital statistics data. Finally, O'Brien-Pallas, Alksnis et al. (2003a, 2003b) examined only the losses due to retirement and were unconcerned about losses under the age of 50 in the analysis. In other words, they estimated the number of losses in the workforce over age 50, while here we estimate the change in the total size of the workforce under different retirement scenarios (i.e., net change).
3. Variability in Age Distributions and Annual Net Growth Rates

3.1. Age Distributions

The age distribution of nursing groups is significant for several reasons. First, it is an indicator of the mix of experience in the workforce, as older nurses tend to have more years of experience. Second, a nurse's age may be associated with work patterns. For example, older nurses have more seniority and may tend to work different shifts, or may have different preferences as to the number of hours that they work. Finally, the percentage of nurses at the older ages will be a major determinant of the number of retirements that will occur in the near future, and any “bulges” in the age distribution are likely to result in future surges in the number of retirements in the future. Thus, along with the levels of annual net growth rates by age, the age distribution is a very important determinant of future supply.

Figures 2 to 16 show how the age distributions of the three professional nursing groups differ from each other, how they differ by province, and how they differ by sector of employment. Data was grouped together in three-year age groups to smooth the lines, and make the graphs easier to interpret. The value of each three-year age group is an average of the number of nurses within that age group. The lines in the graphs show the percent of all nurses, in a professional group (or a professional group and sector of employment) that are in a particular age group. For example, Figure 2 shows that approximately 4% of all LPNs in Canada aged 24-65 are in the 24-27 age group, while slightly more than 3% of all LPNs in British Columbia aged 24-64 are in the 24-27 age group. Thus, British Columbia has a smaller percentage of LPNs in the youngest age group than Canada as a whole.

3.1.1. Age Distribution of LPNs

Figures 2 to 6 show how the age distribution of LPNs differs by province. Each graph also includes the age distribution for all LPNs in Canada for comparison. The following observations can be made from these Figures:

- In all of the provinces, with the exception of the north, the age distribution of LPNs is concentrated at the older ages. Thus, in the next 10-15 years, retirements will be a major factor affecting the supply of LPNs.
- The western provinces, including Alberta, British Columbia, Saskatchewan and Manitoba have somewhat older age distribution of LPNs than Canada as a whole (Figures 2-3).
- Ontario and Quebec have age distributions of LPNs that are close to the age distribution of LPNs in Canada as a whole. Of course, one reason for this is that the majority of LPNs in Canada are located in these two provinces (Figure 4).
- The Atlantic provinces have somewhat younger age distributions of LPNs than Canada as a whole (Figures 5-6).
- The north has a relatively young age distribution, and shows a marked concentration of LPNs under the age of 35. However, because the numbers of LPNs in the north is relatively small, and the level of turnover is quite high, the age distribution is likely to fluctuate from year to year (Figure 6).
3.1.2. Age Distribution of RNs

Figures 7 to 11 show how the age distribution of RNs differs by province. As with the previous set of graphs, each graph includes the age distribution for all RNs in Canada for comparison. The following observations can be made from these Figures:

- All provinces, with the exception of the Province of Newfoundland and Labrador, have a high concentration of RNs in the older ages. Thus, in the short term, retirements will be a major factor affecting the supply of RNs.
- British Columbia has a slightly older age distribution of RNs than Canada as a whole (Figure 7).
- With the exception of Prince Edward Island, the Atlantic Provinces have younger age distributions of RNs than Canada as a whole. This is especially the case for the Province of Newfoundland and Labrador (Figure 10).
- The remainder of the provinces and the North have age distributions of RNs that closely mirror the age distribution of Canadian RNs as a whole.

3.1.3. Age Distribution of RPNs

Figure 12 shows the age distributions of RPNs for all the provinces for which they are a regulated profession. The following observations can be made:

- Just as for LPNs and RNs, RPNs in Canada as a whole are concentrated at the older ages. However, there is considerable diversity in the age distribution between provinces. In part, this reflects the smaller numbers employed in this profession.
- British Columbia has a markedly older age distribution than the other provinces. RPNs in British Columbia are heavily concentrated in the ages over 49. Thus, retirements over the next fifteen years will be a critical factor affecting supply.
- Alberta has a relatively broad age distribution, with a roughly equal proportion of RPNs between the ages of 35 and 55.
- Saskatchewan has a relatively young age distribution.
- Manitoba's RPNs are heavily concentrated in the middle years. Thus, while Manitoba is likely to face relatively small declines in supply due to retirements in the short-term, it can anticipate large number of retirements starting in 10-15 years.

3.1.4. Differences in Age Distributions between the Professional Groups

Figure 13 compares the age distributions between the three regulated professional groups for Canada as a whole. This graph clearly shows that all three of the regulated professions have similar age distributions. All three groups have a high concentration of nurses in the older age groups.
3.1.5. Differences in Age Distribution by Sector of Employment

Figures 14 to 16 show how the age distribution of each of the three professional groups differs by sector of employment. There are some interesting contrasts between the professions. For LPNs, the age distribution of those employed in the hospital sector is older, and more concentrated in certain age groups, than the age distribution of nurses employed in other sectors (Figure 14). However, the reverse is true for RNs. The age distribution of RNs in the hospital sector is younger than the age distribution for those employed in other sectors (Figure 15). For RPNs, the age distribution is similar between employment sectors (Figure 16).

3.2. The Age Pattern of Annual Net Growth Rates: Variation by Professional Group and Province

As addressed in the methods section of the report, annual net growth rates reflect the difference between the number of new nurses of a given age who enter the workforce in a year, and the number of nurses of a given age who leave the workforce over a year. Essentially, they are combined recruitment and retention rates. Along with age distribution, the age patterns of annual net growth rates (and the changes that occur in them over time) determine the future supply of nurses in the workforce. Moreover, as the simulation models will show, in the long-term, it is the recruitment and retention rates at each age that determines the age structure. Thus, the annual net growth rates are the most important determinant of supply in the long run.

Figures 17 to 28 describe how the age pattern of annual net growth rates varies between the professional nursing groups, and between provinces. In the case of RNs, where data was available to compute annual net growth rates by year, Figures 17 to 19 show how the rates vary over time. Unfortunately, this could not be assessed for LPNs and RPNs because only two years of registry data was available. Graphs 20 to 28 show how annual net rates of growth differ by province. In each graph, the data points indicate whether a particular age cohort of nurses is growing or declining. A horizontal line in each graph marks a net growth rate of zero. The line differentiates age groups for which the supply is growing and age groups for which supply is declining. Data points below the line indicate net decline in the number of nurses, while data points above the line indicate net growth in the number of nurses. Also note that the graphs are organized by age. For example, Figure 17 shows rates for ages 25-30, Figure 18 shows rates for ages 31-54, and Figure 19 shows rates for ages 55-64. This is because the rates observed in these three age groups are generally very different. The ages 25-30 are generally characterized by growing age cohorts. It is during these ages that newly educated nurses and migrants are usually entering the workforce. Ages 31-54 characterize the middle period of nurses’ careers, and generally are characterized by rates that are closer to zero. Migration and temporary entries and exits from the workforce are important determinants of growth rates over these ages. Between the ages of 55 and 64, net growth rates are generally negative as the numbers of nurses is depleted by retirements.
3.2.1. Variation in the Age Pattern of Annual Net Growth Rates by Year: 1993-2003

Figures 17-19 show how the annual net growth rates varied over time. The following observations can be made:

- The annual net growth rates are remarkably variable over time in all three age groupings. For example, in nearly all ages annual net growth rates vary by at least 10 percentage points. However, it should be noted that some of this variation may be due to errors in self-reported employment status, and higher annual net growth rates for 2002-2003 reflect changes in the methodology used to handle missing data on employment status (see methods section). The large degree of variation in annual net growth rates highlights the limitations of forecasting models and projections that assume that annual net growth rates remain stable over long periods of time.

- Low annual net growth rates for RNs are concentrated in the early to mid-1990s. During this period, federal and provincial efforts to control expenditures and restructuring in the health care sector resulted in layoffs, cutbacks to nursing education programs, and reduced employment prospects.

3.2.2. Variation in Annual Net Rates of Growth by Province

Figures 20 to 28 show how the annual net growth rates vary by province and professional group. There are three graphs for each professional group, corresponding to ages 25-30, 31-54 and 55-64.

3.2.2.a. Licensed Practical Nurses

Figures 20 to 22 describe the rates for LPNs. It should be noted that the annual net growth rates for LPNs are generally very high in magnitude, and as discussed in section 2.3 are of suspect quality. They should thus be interpreted with caution, and probably overestimate the true value of annual net growth rates. With this caution in mind, the following observations can be made:

- For the 25-30 age group, the magnitude of estimated rates is exceptionally high, often exceeding 20% (Figure 20). As discussed above, we believe that these rates are implausibly high, and likely reflect data problems. If these rates are correct, they are unlikely to remain at this level in subsequent years. The highest annual net rates of growth appear in the West, especially British Columbia.

- In the 31-54 age group, the rates are also suspiciously high in magnitude (Figure 21). The estimated rates for Canada as a whole, and also Ontario, are positive over virtually the entire age range. The highest estimated rates are in the West, while the lowest estimated rates appear in Newfoundland and Labrador and Saskatchewan.

- For the 55-64 age group, with the exception of Ontario, estimated rates appear more plausible (Figure 22). All are less than zero, reflecting depletions in supply from retirement. In several provinces, there appear to be a large number of retirements around the age of 60 (BC, NB,

3.2.2.b. Registered Nurses

Figures 23 to 25 show the age pattern of annual net growth rates for RNs. The following observations can be made:

- In the 25-30 age group, positive rates persist across the age range in most provinces; although they decline with age (Figure 23). This likely reflects growth in the workforce due to the entry of new graduates.

- In the 25-30 age group, there are also substantial differences between provinces in the magnitude of the rates (Figure 23). Annual net growth rates are highest in Ontario, and also high in Alberta and British Columbia. This contrasts with much lower rates in the Atlantic region (with the exception of PEI, where large rates likely are due to instability of the estimates due to small numbers). Inter-provincial migration is likely an important contributor to these provincial differences.

- In the 31-54 age group, annual net growth rates are closer to zero, and follow a clear pattern with age (Figure 24). The growth rates are positive in the younger ages, and shift to negative in the older ages. In other words, numbers of nurses are growing at ages 30 to 40, and then the number of nurses begins to decline as nurses approach age 50. In a number of provinces, the rates drop sharply after age 50, probably due to early retirements.

- In the 31-54 age group, the highest rates are observed in British Columbia and Alberta (rates for Prince Edward Island are also high, but these rates are unstable due to the small number of RNs) (Figure 24). Alberta in particular experienced growth over most of the age range. Much of the growth in Alberta and British Columbia may be due to inter-provincial migration, and be at the expense of other provinces; although both provinces have also made major investments in increasing their enrollments in education programs. With the possible exception of Prince Edward Island, the Atlantic Provinces experienced the lowest rates, with decline in supply evident across most of the age range.

- In the 55-64 age group annual net growth rates are negative over most of the age range in all provinces (Figure 25). This suggests high rates of early retirement. Large numbers of exits are evident in most provinces at age 60, and may reflect incentives created by retirement policies and pension plans.
3.2.2.c. Registered Psychiatric Nurses

Figures 26 to 29 show the age pattern of annual net growth rates for RPNs. The following observations can be made:

- Alberta has a relatively small number of RPNs, and thus the rates are highly variable. They should be interpreted with caution.

- In the 25-30 age group, the annual net growth rates for Canada are quite low in magnitude, and even negative through age 27 (Figure 26). Growth is concentrated in the ages 28-30. However, Saskatchewan rates indicate decline for all ages.

- In the 31-54 age group, rates decline with age, but are generally positive over the age range (Figure 27). Saskatchewan rates indicate growth in supply at most ages, which contrasts with the province's experiences in the young age group.

- For the 55-64 age group, the rates are largely negative as would be expected, except for Alberta (Figure 28). Declines are particularly pronounced around age 60. Only in Saskatchewan are retirements concentrated closer to age 65.
4. Simulations of the Effect of Age Distribution and Annual Net Growth Rates on the Future Age Structure and Size of the Nursing Workforce

The future size of a population is a function of three basic factors. First, it is a function of the number of new entrants to the population in each future year at each age. In nursing, new entrants come from education/training programs, immigration, and from returning to nursing from another line of work. It is assumed that the largest rates of entry to nursing will be at the younger ages. Second, future size of the population is a function of the number of exits in each future year at each age. In nursing, exits result from retirement, death, long-term disability, or leaving the profession. It is assumed that rates of exit will generally be larger at the older ages. Third, because the rates of entry and exit from a population generally differ depending on age, future population size is also a function of the initial age distribution of the population. For example, since rates of exit from nursing are larger at older ages (especially due to retirement), the number of exits will depend on the proportion of all nurses that are older. Complexity arises from the fact that entry and exit rates do not remain stable over time and the rates vary as a function of other system factors.

In this section of the report, the impact of age distribution, entry rates, and exit rates on the future supply of nurses within the current demographic context of the three regulated nursing professions is examined. It is important to point out that the entry rates and exit rates (i.e., recruitment and retention rates) cannot be directly observed in the data available for this study. However, the rates are captured jointly by the estimates of annual net growth rates for single year age cohorts that were obtained from CIHI data.

The approach in this study differs in approach from forecasts and projections. Most forecasts and projections attempt to make informed assumptions as to future values of entry and exit rates to predict future supply (Smith et al., 2001). However, because the margin of error in these assumptions increases with the time horizon, forecasts are only reliable in the short term. In the simulation approach employed in this study, we test the sensitivity of assumptions; evaluate the impact of variation in annual net growth rates over time; and uncover the dynamics of the system in the long-term. By long-term, we mean a period of 45 years, which covers the full working career of a cohort of nurses. Simulations of this duration are necessary to uncover model dynamics that cannot be seen in short-term simulations.

If simulations cannot reliably predict the size of the workforce in the future, what is the value of long-term simulations? We have addressed this question in Section 2.4.3, but because of its importance reiterate it here. As we showed using an illustrative example of the use of modeling to evaluate China's population policies, long-term modeling is critical for assessing the long-term implications of current policies. Long-term modeling is also critical for understanding system dynamics. Mathematical models and simulations of populations have explained the inter-relationships between age-specific death rates, age-specific birth rates, the age distribution of the population and population growth rates (Keyfitz, 1978). They show, for example, that the current age distribution of a population is entirely determined by the past history birth and death rates. This age distribution in turn exerts a strong impact on future growth of the population, and places strong constraints on efforts to plan and control future growth. Moreover, models have shown that a population experiencing fixed birth and death rates will converge, over time to a “stable population” with a constant age structure, and a constant rate of growth. While
stable populations do not occur in reality, because birth rates and death rates in population do not remain
stable, models of stable populations have had broad practical applications in population policy and planning.
Population models have formed the foundation of demography, actuarial science and population biology,
and have had broad practical applications in population planning, management of pension plans, and life
insurance planning.

It is interesting to note that there has been little work on developing and examining the dynamics
of similar models for nursing or other health professions. The dynamics of nursing populations differ in
important respects from general population dynamics. However, as the simulation models we present
in this report will show, the population dynamics of the nursing workforce share many of the features of
the population dynamics of classic demographic models of the human population. As in other fields,
these models have important implications for planning.

4.1. The Effect of Initial Age Distribution and Annual Net Growth Rates on
Future Workforce Size and Age Distribution

Initially, the basic population dynamics of future nursing supply were explored. Four scenarios
were compared by varying two input parameters: the initial age distribution (young versus old) and the
age pattern of annual net growth rates (high versus low). The impact of varying these two parameters on
the future supply of nurses, and future age distributions, for a period of 45 years was examined.

4.1.1. Scenarios and Assumptions

The definition of young versus old initial age distribution was obtained by drawing on the analysis
of observed age distributions from section 3 of this report. The young age distribution was drawn from
the age distribution of registered nurses in Newfoundland & Labrador. Newfoundland and Labrador has
one of the youngest observed age distribution among the nursing groups and provinces we examined.
However, it should be noted that its age distribution is still relatively old in comparison to the age
distributions we are likely to see in the future. The old age distribution was drawn from the age
distribution of registered nurses in British Columbia, which has one of the oldest observed distributions.

The definition of high versus low annual net growth rates was obtained in a similar fashion. For a
set of low annual net growth rates (i.e., low recruitment and retention), the 2001-2002 rates for registered
nurses in Manitoba were employed, which showed losses across most of the age range. For a set of high
annual net growth rates (i.e., high recruitment and retention), the 2001-2002 rates for registered nurses
in British Columbia were employed.

Four simulation scenarios were run. The impact of high versus low annual net growth rates was
evaluated when applied to both young and old initial age distributions. Each scenario was applied to a

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4 In particular, the rate of entry of new nurses into the population is not directly analogous to birthrates. Birthrates are a
function of the proportion of women in the child-bearing ages, which is in turn a function of birth rates 20 - 40 years previously.
4.1.2. Results

This simulation clearly illustrates two important findings that will be stated before exploring them in more detail:

1) The size of any nursing population that experiences stable annual net growth rates by age will eventually converge to a fixed population size. This will happen regardless of the shape of the initial age distribution over a period of 35 to 45 years. In other words, there is an implicit population size associated with any age pattern of annual net growth rates.

2) The age distribution of any nursing population that experiences stable annual net growth rates will converge to a fixed age distribution, regardless of the initial age distribution. This will also happen in 35-45 years. Thus, there is also an implicit age distribution associated with any age pattern of annual net growth rates.

These two findings are important because they provide a way to estimate the long-term consequences of current recruitment and retention rates. In fact, out of these two findings come two new indicators that can be employed in health human resource planning.

Simulations showing the convergence of populations to an implicit size (the first key finding) are shown in Figure 29. The figure shows the simulated trends in population size for each of the four scenarios over a 45-year period. The top pair of lines shows the effect of high annual net growth rates on a young versus old initial age distribution and the bottom pair of lines shows the effects of low annual net growth rates on a young versus old initial age distributions. The initial age distribution affected population size for the first 35 years, and especially between five and 25 years. For example, for the low annual net growth rate scenarios, the old and young population both stabilized at the same level (approximately 3,500 nurses), but the older population did this much more quickly. Its decline was more rapid and of shorter duration. For the high annual net growth rate scenarios, the young age distribution experienced a period of rapid growth followed by a period of decline before stabilizing at about 13,000, while the old population experienced relative stability and then growth before stabilizing. In the long-term, this Figure shows that the effect of initial age distribution entirely disappears, and both pairs of lines converge to a fixed population size. The population with high recruitment and retention converges to a stable population size of approximately 13,000 and the population with low recruitment and retention converges to a stable population size of approximately 3,500. So, what this means is that trends in population size in the short-term are heavily affected by age distribution, but in the long-term population size is determined only by rates of recruitment and retention.

Results from the simulations showing how populations with high annual net growth rates converge to an implicit age distribution (the second key finding) are shown in Figures 30 to 33. These Figures show the age distributions of initially young and old population at different time periods in the simulation.
The old population experiences little growth in the first 20 years (red line, Figure 29) because the initially high concentration of nurses at the older ages is experiencing retirement (blue bars, Figure 31). However, by year 25 the initial concentration of older nurses have all retired (Figure 32), and the population starts to grow rapidly (red line, Figure 29). The experiences of the young population are initially quite different. Up until 20 years, the young population experiences rapid growth (blue line, Figure 29) because only the smaller initial cohorts are reaching retirement age (Figures 30 and 31, red bars). However, between 20 and 35 years, the larger initial cohorts reach retirement age, and the population actually experiences decline. By 45 years, both young and old populations have converged to the same age distribution (the implicit age distribution), which has a relatively high concentration at the older ages (Figure 33). So, regardless of what the initial age distribution looks like, a population with high rates of recruitment and retention (growth at most ages) will converge to an older implicit age distribution.

A similar convergence to an implicit age distributions can be seen when young and old initial age distributions experience low annual net growth rates (Figures 34 to 37). However, the implicit age distribution for a population with low annual net growth rates (Figure 37) looks very different than the implicit age distribution for a population with high annual net growth rates (Figure 33). A population with low annual net growth rates converges to a younger age distribution. So, populations with low rates of recruitment and retention will tend to converge to younger age distributions, while populations with higher rates of retention and recruitment will tend to converge to older age distributions. This shows that the retention in the workforce is an important determinant of the proportion of the workforce with high levels of experience (i.e., older nurses) and will also indirectly affect labour supply (because older nurses have different work patterns).

The implicit size of the workforce and the implicit age distribution are relatively easy to estimate, and can serve as useful indicators for health human resource planning. Clearly, nursing populations will not converge to an implicit size and age distribution in reality because annual net rates of growth (i.e., rates of recruitment and retention) will not remain constant over time. However, just as in the example of China's one child policy given above, these numbers are an indicator of the long-term implications of current policies and labour market experiences. They tell us the direction we are going, and indicate the degree to which current recruitment and retention are sustainable. If the implicit workforce size and age distribution are implausible or inconsistent with expected future needs, then efforts need to be made to change recruitment and retention rates. Moreover, indicators of implicit workforce size and age distributions can also be computed to help identify target rates of recruitment and retention.

4.2. The Effect of Increasing the Number of New Graduates on Future Workforce Size

A common policy response to addressing shortages is to increase the number of training seats, and thus the number of graduates entering the workforce. What is the impact of this on future nursing supply? How does it interact with the level of annual net growth rates? Simulations were run to answer these questions.
4.2.1. Scenarios and Assumptions

As with the previous set of simulations, the models were initialized with a hypothetical population of 10,000 nurses. The initial age distribution was set to the “young” age distribution used in the previous set of simulations. We also ran these simulations on the “old” age distributions used in the previous set of simulations, and it resulted in the same findings. Accordingly, only the results for simulations on the young age distributions are presented.

The impact of increasing the number of new nursing graduates entering the workforce was examined by adding new nurses to the youngest age group each year. A baseline scenario was established with 140 new nurses added each year to the youngest age cohort. It should be noted that this does not mean that only 140 new graduates are added to the population each year. Regardless of whether low or high annual net growth rate scenarios are used, the rates are positive in the youngest age groups, and thus there is net growth. Thus, the addition of additional new graduates to the workforce in the younger age groups is implicit in all scenarios. A second scenario was developed where we added 200 new nurses each year (an increase of 60 per year over the baseline scenario). For a third scenario, 300 new nurses each year (or an increase of 160 per year over the baseline). The impact of these three scenarios on future supply was simulated using for populations with both low and high annual net growth rates.

4.2.2. Results

Figures 38 and 39 compare the impact of increasing the number of nursing graduates in populations with low versus high levels of annual net growth rates. In comparing these graphs, it is important to note the differences in the scales used for population size on the y-axis of the graphs.

The primary conclusion to be reached from these simulations is that the increase in size of the workforce achieved by increasing the number of new graduates depends a great deal on retention. If retention of nurses in the workforce is poor, many new graduates will eventually exit the workforce, and thus the increase in population size will be smaller. For example, adding 60 additional new graduates per year to a population with low annual net growth rates (i.e., low retention) results in an implicit workforce size (the stable size to which the population converges) with only 1,500 more nurses (red versus green lines at 45 years in Figure 38). On the other hand the same increment of 60 graduates per year in a population with a high annual net growth rate (i.e., high retention) results in an implicit workforce size with approximately 5,000 more nurses (red versus blue lines at 45 years in Figure 39).

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5 To implement this scenario, we added incremental numbers at age 25 only, and allowed the annual net growth rates at subsequent years. We simulated the addition of new nurses in this fashion for reasons of technical feasibility. Varying the age at which nurses were added has only small impact on model outcomes, and does not alter the conclusions of this analysis.
4.3. The Effect of Changes in the Age of Retirement on Workforce Size

Previous work shows that Canada is expected to lose a large share of its current registered nurse workforce to retirements by 2006 (O'Brien-Pallas, Alksnis et al., 2003a, 2003b). O'Brien-Pallas and team demonstrated that if all registered nurses retired at age 65, 13% of the current workforce would be expected to retire. However, this increases to 28% if all nurses retired at age 55. In light of these numbers, there is considerable interest in the effect of changes in the average age of retirement on future nursing supply. These sets of simulations examine the short versus long-term impacts of changes in the age of retirement.

4.3.1. Scenarios and Assumptions

Four scenarios were run to examine the effect of age of retirement on the future nursing supply. The effect of current retirement patterns were compared with full retirement at age 55 and retirement only at age 65. This was carried out using both old and young initial age distributions. Clearly, no such variations in age of retirement could occur in reality, but using these extreme scenarios provides a means of understanding the maximum possible effect of age of retirement on supply. Young and old initial age distributions were defined the same as in previous simulations. To simulate current retirement patterns we used the smoothed average annual net growth rates for Canada based on 1999-2002 data for RNs. To simulate full retirement at age 55, we held annual net growth rates constant at the average levels for Canadian RNs up to the age of 54, and then introduced an annual net growth rate of -100% (i.e., 100% loss) at age 55. To simulate retirement at age 65, we held the net annual growth rate to the level of Canadian RNs to age 54, and then included an annual net growth of -1% per year up age 64, and a rate of -100% at age 65. We included a low rate of negative growth from ages 55-64 to allow for loss due to factors such as death and disability.

4.3.2. Results

The results of this simulation are shown in Figure 40. The results show that changing the age distribution of retirements will have a much bigger impact on supply in the short run than in the long run. The following conclusions can be made:

- In the long-term, the simulation suggests that shifting the current retirement pattern of Canadian RNs to retirement at age 65 would have a relatively small impact on the implicit size of the workforce. An initial population of 10,000 nurses with retirement at age 65 would converge to have about 400 more nurses than the same population with a pattern of retirements similar to Canadian RNs. Relative to a population with full retirement at age 65, a population with full retirement at age 55 would converge to having approximately 1,500 fewer nurses.

- Consistent with the findings of O'Brien-Pallas, Alksnis et al. (2003a, 2003b), changes in the age of retirement can have large short-term impacts on the size of the workforce. This is especially true for a population with an old age distribution. The simulations show why this is so. In addition to changing the implicit size of the workforce, changing the age of retirement affects the timing and speed of changes in workforce size resulting from the effects of age distribution.
For example, compare the old age distribution scenario for retirement at age 65 (purple line) and the old age distribution scenario for retirement at the rates of Canadian RNs (yellow line). In both cases, the scenarios indicate large declines in the size of the workforce. However, the age 65-retirement scenario does not decline below the initial workforce size for eight years, while the Canadian RN scenario declines immediately. On the other hand, when the age 65-retirement scenario does decline, the decline is steeper.

- These findings suggest that changes in the age of retirement can be an important short-term strategy to cope with decreases in workforce size resulting from an aging workforce. By changing the age of retirement, planners can alter the timing and speed of declines in workforce size.
5. Simulations of Nursing Groups by Province

In this section, the results of two sets of simulation models for specific provinces and nursing groups are presented. The first set of simulations estimated two new indicators for health human resource planning derived from the general simulations in section 4: the implicit workforce size and implicit age distribution implied by current annual net growth rates. They show what the long-term implications would be of current training levels and labour market experiences of nursing groups on the future workforce. The second set of simulations was run to update and extend previous work on retirement scenarios that has been conducted by the research team (O’Brien-Pallas, Alksnis, et al., 2003a, 2003b). The simulations show the impact of changes in the age of retirement on the size of the nursing workforce over the next ten years. A more detailed description of the methods can be found in section 2.4.3.c.

5.1. Where are provinces headed in the long-term: implicit workforce sizes and age distributions

5.1.1. Registered Nurses

The top panel of Table 1 in Appendix B shows the implicit workforce sizes estimated for Canada and the provinces, and Figures 41 to 51 show the implicit age distributions implied by current annual net growth rates being experiences by RNs. The following observations can be made:

Estimates of implicit workforce size show that, if current recruitment and retention rates by age remained unchanged, the workforce would converge to a size considerably smaller than the current workforce. The estimated implicit workforce size for Canada as a whole, and for all of the provinces, is substantially smaller than the current workforce size; although there is considerable variability between provinces. The implicit workforce size for Canada as a whole is 36% smaller than the size of the current workforce (Table 1). Implicit workforce sizes for the provinces range from 14% to 78% smaller than the current workforce size.

It is important to note that the implicit workforce sizes are purely a reflection of recruitment and retention rates, and are independent of the current age distribution of nurses. In other words, even if the current workforce did not have a large proportion of nurses approaching retirement age, current levels of recruitment and retention imply a considerably smaller workforce. Whether or not these values indicate that recruitment and retention need to be improved as a long-term planning goal depends on future population health needs. However, a number of provinces have implicit workforce sizes that are more than 60% smaller than their current workforce.

In Figures 41 to 51, it can be seen that current recruitment and retention rates imply age distributions that are substantially younger than the current age distributions characterizing the RN workforce. Only Prince Edward Island has an implied age distribution with a high concentration of RNs near retirement age (Figure 49). However, the number of nurses used to compute annual net growth rates for Prince Edward Island is quite small, and thus the rates tend to fluctuate from year to year. Thus, the margin of error in the implicit age distribution may be quite high. Alberta also has a somewhat old implicit age distribution (Figure 43). This is a reflection of the relatively high annual net growth rates at older ages, and may reflect recruitment of nurses from other provinces.
Some provinces have young implicit age distributions (e.g., New Brunswick), which is a concern because it implies a shortage of more experienced workers (Figure 48). A young implicit age distribution is a result of low rates of retention of nurses in the workforce in the middle and older ages. Thus, young implicit age distributions emphasize the need for ongoing policies to improve retention of nurses who are in the middle and end of their careers. This is a good illustration of the value of this indicator because the provinces with young implicit age distributions (a long-term problem) are facing imminent shortages resulting from populations that are currently aging (a short-term problem). This indicator thus emphasizes the need for those provinces to balance retention at the older ages (a long-term planning priority) with increased recruitment and retention at the younger ages (a short-term strategy to cope with imminent shortages). An over emphasis on the younger ages could have the effect of shifting the implicit age distribution to even younger ages.

5.1.2. Registered Psychiatric Nurses

The bottom panel of Table 1 shows the implicit workforce sizes for RPNs, while implicit age distributions are shown in Figures 52 to 56.

The RPN indicators of implicit workforce size and age distribution should be treated as very tentative. These estimates are based on annual net growth rates computed from only two years of data (versus four years for RNs), and thus are likely to reflect the unique experiences of a single year. Moreover, since it is a relatively new database, it may not be as accurate, and the total number of RPNs upon which the annual net growth rates are computed is much smaller than it was for RNs. Accordingly, the estimates of implicit workforce sizes and age distributions are much less reliable. This means, for example, that revised estimates using 2004 data, when it becomes available, are likely to differ considerably from the estimates we present. The reliability of estimates will improve significantly as additional years of RPN data become available, but for now they should be interpreted with great caution.

The implicit workforce size for Canadian RPNs, overall, is nearly 60% smaller than the size of the current workforce. Thus, current rates of recruitment and retention imply a much greater decline in workforce size than for RNs. There is also considerable variability between the provinces in the difference between current and implicit workforce sizes. Saskatchewan has an implicit workforce size that is 80% smaller than the current workforce, suggesting that the pattern of recruitment and retention rates observed between 2002 and 2003 cannot sustain the workforce in the long-term (Figure 55). British Columbia (Figure 53) and Manitoba (Figure 56) have differences between current and implicit workforce sizes that are similar to those for Canada (Figure 52) as whole. The implicit workforce size for Alberta (Figure 54) is peculiar, implying a doubling of the workforce. This is implausibly large, and is likely the result of unusual annual net growth rates between 2002 and 2003.

The implicit age distributions for RPNs (Figures 52 to 56) are highly variable, and in part may reflect poor reliability of the estimated annual net growth rates upon which they are based. Both Saskatchewan and Alberta have implicit age distributions that are very old. Saskatchewan's implicit age distribution is a result of the unusual pattern of annual net growth rates by age that was observed in section...
The rates implied poor retention at the younger age groups (negative growth between ages 25 and 30), and high retention and recruitment between the ages of 31 and 54 (net growth). The reasons for this peculiar pattern need to be explored to assess whether it is driven by data quality problems or unusual labour market events. Results in section 3 (Figures 26 to 28) also revealed peculiar patterns of annual net growth rates by age.

5.2. Short-term retirement scenarios

5.2.1. Registered Nurses

Results from the simulations of 10-year retirement scenarios for RNs in Canada, overall, and each province are shown in Figures 57 to 67.

Figure 57 shows that different retirement scenarios for Canada as a whole can have large short-term impacts. If current retirement scenarios prevail, the simulation suggests that RN workforce size would decline by approximately 5,000 (2% of the current workforce) in five years and 20,000 (9% of the current workforce) in 10 years. On the other hand, delaying retirement has the potential to stem this decline. Under a best-case scenario of full retirement at age 65, the workforce size would remain relatively stable over the 10-year period. Thus, keeping older nurses in the workforce longer has the potential to “buy time” to ramp up training programs and implement policies to improve retention across the age span. However, as the retirement simulations in section 4.3 show, this is likely to come at the price of a more rapid decline in retirements following the 10-year horizon of this simulation.

The worst-case scenario simulation for Canadian RNs, full retirement at age 55, shows that short-term shifts in the workforce to earlier retirement has the potential to dramatically accelerate the decline in workforce size associated with an aging workforce. Thus, policy makers must be attentive to factors that would promote early retirement. There is a risk that the quality of the work environment and deteriorating job satisfaction among nurses resulting from increased workloads and other factors could lead more RNs to retire early.

The province-specific retirement simulations for RNs all lead to similar conclusions. Changes in retirement can have large short-term impacts on the timing and speed at which changes in workforce size due to the aging of RN workforces occur. What differs between provinces is the baseline trend in workforce size. In some provinces, such as Nova Scotia (Figure 66), New Brunswick (Figure 64), Manitoba (Figure 61) and Saskatchewan (Figure 60) anticipated short-term declines in workforce size are expected, regardless of retirement scenario. Slowing the decline in workforce size may thus be more critical. On the other hand, both the status quo scenario and the best-case scenario for Alberta result in increases in workforce size (Figure 59).
5.2.2. Registered Psychiatric Nurses

The results for the RPN retirement simulations are shown in Figures 68 to 72. It must again be emphasized that the results for these simulations should be interpreted with great caution. Estimates of the annual net growth rates upon which they are based may not be reliable because of the availability of only two years of data, relatively small numbers of RPNs, and data quality issues.

The simulations for RPNs in Canada overall (Figure 68) lead to conclusions that are very similar to those for RNs. Alternative retirement scenarios can result in substantial differences in the timing and speed of short-term changes in workforce size. Thus, policies to delay retirement may be a fruitful strategy to “buy time” for other policy and system changes. However, it should again be emphasized that the simulations in section 4.3 suggest that this may come at the price of more rapid declines in supply beyond 10 years. Unlike RNs, there were considerable differences in the province-specific results. As with the simulations in section 5.1, this reflects unusual patterns of annual net growth rates by age in Alberta (Figure 70) and Saskatchewan (Figure 71).
6. **Conclusions and Recommendations**

6.1. **Why are we facing a nursing shortage?**

Because of the aging of the nursing workforce, declines in workforce size in the next 10 to twenty years are almost certain. This is one of the most important reasons for the continuing nursing shortage. All three regulated nursing professions have workforces with a high proportion of nurses concentrated in the older age groups. Moreover, while there are some differences between provinces and territories in age distributions of nurses, this problem is shared by all regions of the country. The result is a “demographic time bomb” that will result in a large portion of the current workforce retiring in the near future. In the short-term, the aging of the workforce is a major determinant of future nursing supply, and even if very optimistic assumptions regarding future rates of retention and recruitment of nurses in the workforce are made, Canada and most of its provinces and territories can expect to experience declines in the size of the workforce in all three nursing groups (CNAC, 2002; Ryten, 1997; Ryten, 2002).

Why has this happened? It is the result of a unique set of historical circumstances and policy decisions affecting the nursing labour market over the past 30-40 years that have created the current age distribution. Consistent with the literature on population dynamics, the simulations show that the age structure of the nursing workforce is fully determined by the past history of age-specific rates of entry and exit from the workforce. The current age distribution of all three nursing groups is a reflection of the labour market experiences of nurses over the last 30 to 40 years, and cannot be explained by events in the last two decades alone. Indeed, the large cohorts of nurses now approaching retirement were trained in the 1970s. The high degree of concentration of the workforce in the older age groups is a reflection of large variations in the educational opportunities and labour market experiences of different cohorts of trained nurses (i.e., nurses trained at about the same time). There have been dramatic changes in nursing school enrollments and seats during times of bust and boom. The varied experiences also reflect periods of growth and decline in the number of nursing positions, variations in workforce retention associated with alternative career opportunities, and layoffs associated with downsizing of the acute care sector (which had the most dramatic effects on younger nurses) (O’Brien-Pallas, Alksnis et al., 2003a).

It is important to emphasize the uniqueness of the current age distribution characterizing the nursing professions. The simulations also show that, regardless of future scenarios, it is very unlikely that future age distributions will look anything like the current age distribution. Unless we continue to have shifts in policies and funding for the health care system that create large differences in the labour market experiences of cohorts, future age distributions will be younger and more uniformly distributed by age.

6.2. **How should we respond to the shortage?**

What strategies can we employ to cope with an unusual decline in supply? How can we avoid creating similar crises in the future? Coping with the current shortage requires strategies that will be effective in the short-term to adapt to declines in supply. In particular, strategies to improve the productivity and worked hours of nurses are vital and must augment efforts to increase recruitment and retention. However, it is critical that these strategies be accomplished without deterioration in nurse and patient outcomes. The nursing workforce needs continued study to determine what work characteristics will
lead to best retention and attract nurses to the profession. O’Brien-Pallas, Thompson et al. (2003) found that high production/utilization expectations are leading to increased costs per case, higher rates of absenteeism and expressed intent to leave, and poor patient outcomes. Reducing workload expectations will be an important step in retaining nurses. We also need to concentrate on getting nurses into the workforce at an earlier age so that their time in the workforce is longer. Incentives to come into nursing early and to stay in nursing longer will help alleviate the impact of the demographic time bomb. Improvements in technology may also partially defuse the impact of nursing shortages.

However, in developing strategies to cope with more immediate supply shortages, planning must also consider the long-term implications of policies on nursing supply. We can no longer rely on short-term fixes to deal with immediate shortages, especially if they may have negative long-term implications (examples are given below). A long-term perspective is necessary to avoid creating future crises such as the one we are now experiencing. How can this be accomplished? First, the number of nurses trained must be targeted and adjusted on an ongoing basis to meet estimated needs of the population well into the future. Models and estimates of future need must consider changes in population demographics and population health status. They must also consider likely changes in the deployment of nurses and other inputs (technology, other health professionals) to meet those needs. Second, policies are needed that enhance the retention of working nurses for as long as possible in the workforce, and maximize their productivity. Studies like the O’Brien-Pallas, Thompson et al. (2003) study on evidence based staffing need to be completed in all sectors. Given that the health care needs and how we meet those needs will continue to advance over time as technological breakthroughs emerge, the work environments will continue to change at the same time. Ongoing repetitions of studies that examine best policy practices for work environments will need to be repeated at five-year intervals over the next half century. Finally, policy makers need longer-term policies, based on effective planning, that create the conditions for a more uniform age distribution that do not result in future cyclical shifts in supply. This can be accomplished by including the monitoring of age distributions in human resource planning, developing policies that help ensure the stability of labour market experiences across cohorts of nurses, and incorporating new indicators of long-term supply outcomes in human resource planning. Ongoing simulations and forecasts, repeated at least every 5 years, must support this effort.

The simulations and analysis provided valuable insights on some of the strategies that can be used to address the current shortage of nurses and to plan for human resource requirements in the longer term:

6.2.1. Addressing the nursing shortage exclusively through improved recruitment and training may be a poor long-term strategy.

Diffusing the current demographic time bomb by focusing exclusively on recruitment and training may create a new time bomb with a 40-year fuse. It would require creating a new large cohort of younger nurses to offset the large cohort retiring, and thus sets the stage for a similar demographic crisis in about 40 years. Thus, it may be a shortsighted strategy from a long-term perspective.
A strategy focusing just on recruitment and training is not feasible, at least at the national level, and for most provinces and territories. The simulations show that adding new nurses by increasing training seats takes a number of years before it begins to have a substantial impact on supply. From a national perspective, there is a limited pool of previously trained nurses that could be recruited (from other countries, or by enticing trained Canadian nurses back into nursing). The research team is now engaged in a study that will survey young nurses, nurses who are not practicing, and Canadian trained nurses working in other countries to investigate opportunities and strategies for improved recruitment and retention. Little is known about the size and attributes of this group, and the potential value of this group as a pool of employable nurses.

However, it should be noted that addressing shortage by recruitment alone may be quite feasible for some provinces with sufficient financial resources to attract nurses from other provinces or countries. Such a strategy is not sustainable, nor ethical, from a national perspective. However, the fact that our results suggest this may be a poor long-term strategy provides an additional argument for not pursuing this independent approach. Provincial efforts to recruit trained nurses need to consider the ethical and political implications of immigration from other provinces and countries, and be coupled with other strategies to improve retention.

6.2.2. Increasing the number of training seats must be combined with policies to improve recruitment and retention

Training and recruitment remain an important strategy, but must be combined with other strategies to address and cope with the current nursing shortage. The simulations clearly demonstrate that the effect of increasing the number of training seats on the future size of the workforce depends of the level of retention of nurses in the workforce. Low rates of retention of nurses in the workforce can dramatically erode the gains in supply from increasing the number of training seats.

This has clear implications for policy-makers who may be concerned with the cost of programs to improve retention, and view training and recruitment as a cheaper alternative. The simulations suggest that the cost effectiveness of training and recruitment for increasing supply depend heavily on retention. In other words, high rates of retention are probably required to make investment in training and recruitment cost-effective.

6.2.3. Reducing the rate of early retirement can be an effective strategy for altering the timing of decreases in the workforce resulting from the “demographic time bomb”.

In the long-term, the simulations suggest that the long-term impact of changes in the retirement age on the workforce supply may be quite small, but also show that changes in the age of retirement can be a valuable short-term strategy for coping with the current crisis.

By changing the age at retirement, the timing and speed of declines in supply can be changed as a means to buy time for other strategies, and spread out the losses in supply due to retirement over a longer period of time. Changes in the age of retirement can result in substantial changes in the timing
and speed of declines in workforce supply due to the aging of the workforce. Moreover, results from the simulations, as well as previous work by the team (O'Brien-Pallas, Alksnis, et al., 2003a, 2003b), show that delaying retirement can substantially reduce the number of losses from the workforce over the next five to 10 years. The simulation model we have developed may be a useful tool for planning such strategies.

It should also be noted that retaining older nurses in the workforce is important because of their levels of experience. In the future, simulations suggest that the age distribution of nurses in the workforce will almost certainly be much younger. Indeed, if the labour market experiences of cohorts of nurses are more stable, future age distributions will be more like the implicit age distributions shown in section 4. These distributions have smaller proportions of nurses at the older ages, and a mean age between 35 and 40. Accordingly, retaining the high “human capital” of older nurses will become increasingly important.

6.2.4. The simulations suggest new indicators that can assist long-term human resource planning.

At the beginning of section 6.2, it was suggested that human resource planning should incorporate new indicators of long-term supply outcomes. This is necessary to create a more stable workforce that is not subject to cyclical patterns of growth and decline resulting from unusual age distributions. Two such long-term indicators were derived from the simulations, and were presented by province and nursing group in section 5.

The indicators are derived from a key finding of the simulation, and are similar to indicators used for population planning in demography. The simulations showed that any set of age-specific rates of recruitment and retention of nurses will, if they remain unchanged over time, result in a workforce that (a) converges to a fixed size that remains constant over time, and (b) has a fixed age distribution that remains constant over time. This is true regardless of whether the initial age distribution is old or young. We refer to these as the “implicit workforce supply” and the “implicit age distribution” associated with a pattern of age-specific rates of recruitment and retention.

The implicit workforce supply and age distribution associated with current rates of recruitment and retention are valuable indicators for planning purposes. Clearly, these two values are unlikely to be achieved in practice because recruitment and retention rates will not remain constant over time. However, they provide a long-term indicator of where the workforce supply and age distribution is headed under current policies and conditions. Major deviations of these indicators from reasonable or realistic values are clearly unsustainable and flag the need for changes in recruitment and retention rates. The indicators could also be used to identify how current recruitment and retention rates needs to be changed to bring them more in line with plausible or target values. Combining these “long-term” indicators with short-term indicators (e.g., the results of short-term forecasts) will help planners to identify short versus long-term objectives, and avoid short-term fixes that can cause long-term problems.
6.2.5. **The ability to address shortages in a nursing group or other health care providers through substitution is constrained by supply**

Strategies to address shortages in one professional group by increasing the services from another have been discussed. More specifically, one strategy that has been proposed is to increase the numbers of LPNs in healthcare organizations to adapt to RN shortages, or introduce greater numbers of RNs into primary health care settings to address physician shortages. These strategies may or may not improve the shortage situation. This analysis was not the focus of this step.

However, in order for such strategies to be feasible, there must at least be a potential surplus in substitutable professions. Our analysis showed that all three nursing professions are characterized by similar age distributions. All three have a high concentration of nurses in the older age groups, and all face a similar “demographic time bomb” that will likely result in large decreases in supply in the next 20 years. There is unlikely to be surplus in any of the three professional nursing groups. Augmenting requirements for one nursing group with another or augmenting requirements for other health professions with nurses is unlikely to be feasible.

6.2.6. **Ongoing investment in databases for health human resources planning that are of good quality and comparable is critical**

In this study, we have worked closely with CIHI to access new data sources, and derive new estimates from those sources. We were able to access preliminary versions of the 2003 LPN and RPN registry data (the LPNDB and the RPNDB) and compute estimates of combined recruitment and retention rates.

Given the importance of recruitment and retention to human resource planning, the fact that this is one of the first studies to use national registry data for nursing to estimate recruitment and retention rates for RNs, and the first to do so for LPNs and RPNs is noteworthy. On the other hand, the fact that issues of data quality resulted in estimates of recruitment and retention that could not be used for RNs between 2002 and 2003, or for LPNs, is a concern. The results also raised concerns about the reliability of the results for RPNs as well. This clearly reinforces the need for increased attention to data quality and development.

The data quality problems that we faced in this study were largely due to the employment status variable in the LPNDB, RNDB and the RPNDB. This variable is based on self-report data provided by nurses on their registration forms. Errors in self-report, and more important, missing data for this variable are the fundamental reason for problems in our estimates. CIHI is well aware of this problem, and has worked with the provinces to make major improvements in the accuracy of this variable in the 2003. Indeed, it was the improvement in the variable’s accuracy between 2002 and 2003 that resulted in artificially high estimates of net growth between years. When 2004 data become available, more accurate estimates will be possible.
Nevertheless, despite improvements in the accuracy of the employment status variable, the fact that nurses’ employment status on registration forms only captures their status at a single point in time will always be problematic. We recommend that future estimates of annual net growth in the number of nurses by age using our methods measure entries and exits from active registration, not employment. Such estimates would be more accurate and stable. Employment status should instead be modeled as an attribute of nurses with active registration. Models should conceptually distinguish between the “stock” of nurses that could potentially provide work and the supply of labour provided by that stock of nurses.

This study has only examined workforce supply. Advancing human resource planning requires analysis and simulations of other factors such as population health needs, workload, productivity, and staffing mix. Sources of routine data in these areas, with the possible exception of population health needs, are poorly developed in most provinces and territories, and certainly cannot be compiled for national studies. Moreover, there is a significant paucity of data available outside of the acute care sector. Thus, continued investment and commitment by all stakeholders in new and improved data sources for health human resource planning is critical.
REFERENCES


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THE RESEARCH TEAM

The Nursing Effectiveness, Utilization and Outcomes Research Unit (NRU) has been engaged by The Nursing Sector Study Corporation to conduct research and prepare ensuing reports for Building the Future. The NRU is a network of researchers located in several provinces. The co-directors are as follows.

Linda O'Brien-Pallas, RN, PhD  Andrea Baumann, RN, PhD
Co-Principal Investigator, NRU  Co-Principal Investigator, NRU
University of Toronto  McMaster University

Collectively NRU investigators have established reputations for conducting high quality research on a variety of issues related to nursing and health human resources. Nationally and internationally, the team has established extensive contacts in education, management, research, practice and policy development.

AUTHORS' BIOGRAPHIES

Sarah Maaten, BSc, MSc  Research Analyst, Population Health Research Unit, Dalhousie University

She is a recent graduate of the MSc program in Community Health & Epidemiology at Dalhousie University. Her main research focus has been health services research in chronic disease and health human resource modeling with a particular interest in analytical methods. Sarah was a recipient of the NSHRF Student Research Award in 2001 for her investigation of health service use related to risk factors for chronic disease.

Gail Tomblin Murphy, PhD(c)  Associate Professor, School of Nursing and Community Health and Epidemiology, Dalhousie University and Co-investigator, NRU, University of Toronto

Gail brings expertise in health human resource planning with mounting expertise in needs based approaches to health human resource planning, demand forecasting models, and testing health service delivery models. She has extensive experience working with policy-makers and senior decision makers in Nova Scotia, Newfoundland and Labrador, Prince Edward Island, New Brunswick, Quebec, Ontario, Saskatchewan, Alberta, and British Columbia. During the Romanow Commission, she was invited by Romanow to chair a national roundtable on HHRP, was invited to co-author a discussion paper on HHRP for the Commission, and participated in a roundtable discussion of experts convened in Nova Scotia. Her research has garnered wide-spread interest from governments and other stakeholders because of its potential to significantly impact HHRP policy in Canada. Gail is well funded in Health Services and Health Human Resource Planning research funding from both National and jurisdictional funding agencies, and ministries of health. She co-leads a research team consisting of clinicians, healthcare leaders, policymakers, and researchers from federal and eleven jurisdictional governments, universities and healthcare organizations. A variety of disciplines including nursing, medicine, political science, psychology, bioethics, health economics, labour economics, demography, geography, biostatistics, community health, and epidemiology, and health services administration are represented on this team in order to bring the
necessary experience to examine this very complex area of inquiry. Furthermore, in collaboration with Dr. Linda O'Brien-Pallas, and Dr. Stephen Birch, they have developed a conceptual framework for Health Human Resource Planning and health policy planning. Gail was recently appointed by CIHR (IHSPR) and CHSRF to the role of Science Lead for HHR.
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Note: Data for territories and PEI not shown due to high variability.
Estimated from CIHI LPNDB 2002 - 2003

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Note: Data for territories and PEI not shown due to high variability.
Estimated from CIHI LPNDB 2002 - 2003
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Note: Data for territories and PEI not shown due to high variability.
Estimated from CIHI LPNDB 2002 - 2003

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Note: Data for territories not shown due to high variability.
Estimated from CIHI RNDB 2000 - 2002
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Registered Nurses Age 31-54

Note: Data for territories not shown due to high variability. Estimated from CIHI RNDB 2000 – 2002

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Registered Nurses Age 55-64

Note: Data for territories not shown due to high variability. Estimated from CIHI RNDB 2000 – 2002
Figure 26.

**Annual Net Growth Rates by Age and Province**

Registered Psychiatric Nurses Age 25-30

<table>
<thead>
<tr>
<th>Age</th>
<th>AB</th>
<th>BC</th>
<th>CAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>-50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>50</td>
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<td>0</td>
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</tbody>
</table>

Note: Estimated from CIHI RPNDB 2002 - 2003

Figure 27.

**Annual Net Growth Rates by Age and Province**

Registered Psychiatric Nurses Age 31-54

<table>
<thead>
<tr>
<th>Age</th>
<th>AB</th>
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<th>CAN</th>
</tr>
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<tr>
<td>30</td>
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<tr>
<td>60</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Estimated from CIHI RPNDB 2002 - 2003
Figure 28. Annual Net Growth Rates by Age and Province
Registered Psychiatric Nurses Age 55-64

AB | BC | CAN
---|---|---
55 | 55 | 55
56 | 60 | 65
60 | 60 | 65
65 | 60 | 65

Note: Estimated from CIHI RPNDDB 2002 - 2003

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Figure 64. Retirement Scenarios for RNs in New Brunswick

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Figure 67. Retirement Scenarios for RNs in Newfoundland and Labrador
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Appendix B: Tables

Table 1. Implicit Workforce Sizes Compared to 2002 Workforce Size

<table>
<thead>
<tr>
<th>Province</th>
<th>2002 Population</th>
<th>Implicit Workforce Size</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>27,252</td>
<td>16,235</td>
<td>-40%</td>
</tr>
<tr>
<td>Alberta</td>
<td>22,786</td>
<td>19,380</td>
<td>-15%</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>8,118</td>
<td>2,750</td>
<td>-66%</td>
</tr>
<tr>
<td>Manitoba</td>
<td>9,816</td>
<td>3,092</td>
<td>-69%</td>
</tr>
<tr>
<td>Ontario</td>
<td>77,405</td>
<td>58,076</td>
<td>-25%</td>
</tr>
<tr>
<td>Quebec</td>
<td>57,192</td>
<td>40,095</td>
<td>-30%</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>7,235</td>
<td>3,220</td>
<td>-55%</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>8,313</td>
<td>1,866</td>
<td>-78%</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>1,263</td>
<td>304</td>
<td>-76%</td>
</tr>
<tr>
<td>Newfoundland/Labrador</td>
<td>5,276</td>
<td>3,839</td>
<td>-27%</td>
</tr>
<tr>
<td><strong>Canada - Simulated</strong></td>
<td><strong>225,674</strong></td>
<td><strong>143,770</strong></td>
<td><strong>-36%</strong></td>
</tr>
<tr>
<td><strong>RPN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>2,109</td>
<td>923</td>
<td>-56%</td>
</tr>
<tr>
<td>Alberta</td>
<td>1,060</td>
<td>2,369</td>
<td>123%</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>920</td>
<td>181</td>
<td>-80%</td>
</tr>
<tr>
<td>Manitoba</td>
<td>951</td>
<td>359</td>
<td>-62%</td>
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<td><strong>Canada - Simulated</strong></td>
<td><strong>5,042</strong></td>
<td><strong>2,076</strong></td>
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