Health Workforce Modelling, Northern Territory, 2006 - 2022

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Abbreviations

ABS	Australian Bureau of Statistics
AHW	Aboriginal health worker
AIHW	Australian Institute of Health and Welfare
AR-DRG	Australian Refined Diagnosis Related Group
BoD	Burden of disease and injury
CDU	Charles Darwin University
CCIS	Community care information system
COPD	Chronic obstructive pulmonary disease
DALYs	Disability adjusted life-years
DEEWR	Department of Education, Employment and Workplace Relations
DEST	Department of Education, Science and Training
DHF	Department of Health and Families
DHS	Department of Human Services
FTE	Full-time equivalent
GDP	Gross domestic product
GP	General practitioner
HCSLF	Health and community services labour force
HGP	Health Gains Planning Branch, NT Department of Health and Families
IHD	Ischaemic heart disease
LFS	Labour force survey
NHWT	National Health Workforce Taskforce
NT	Northern Territory
NTG	Northern Territory Government
PCIS	Primary care information system
PIPS	Personnel information and payroll system

Summary

The Northern Territory (NT) medical workforce model and the NT nursing workforce model project the requirement for, and supply of, medical practitioners and registered nurses and midwives (nurses) from 2006 to 2022. The models were produced as part of the Health Workforce Modelling Project established by the Strategic Workforce Committee of the Department of Health and Families (DHF) to inform workforce planning by projecting future numbers of health professionals in the NT. Three reports have been produced under the project. This report presents projections from the medical and nursing models and discusses key issues identified by the modelling. The two other reports provide a technical description and more detail on the outputs from the models.

Growth in population and patterns of population ill health were used to project the future need for treatment and the medical and nursing workforce required to meet that need. To estimate the supply of these health professionals, the current workforce was moved forward in time based on expected inflows and outflows from the workforce including migration, new graduates and retirements; and important trends and influences on those flows.

The key data sources for the models were:

- The Burden of Disease and Injury in the Northern Territory, 1999-2003 (Zhao Y, You J and Guthridge S, DHF)

- Population estimates (NT Government/Charles Darwin University)

- National hospital cost data (Australian Government Department of Health and Ageing)

- Census data (Australian Bureau of Statistics, published by the Australian Institute of Health and Welfare; AIHW)

- Medical Labour Force Surveys and Nursing Labour Force Censuses (AIHW)

- Student data (Charles Darwin University)

The projections from the medical model indicated that over the period 2006 to 2022 growth in the supply of medical practitioners would exceed the growth in requirements for their services. The nursing model initially projected a shortfall, but after 2015 the supply of nurses was expected to exceed requirements. Should these projected increases in supply occur, there would be a greater number of health professionals available to address the burden of disease and injury in the NT. Such an increase could improve access to services and contribute to closing the gap in health status between Indigenous and non-Indigenous Territorians.

The absolute numbers of health professions are, however, less meaningful than the issues that will enhance or impede growth. The modelling highlighted the key impacts on growth. Most critical was the mobility of medical practitioners and nurses. The modelling assumed that past migration patterns would persist into the future. Should the NT become less successful at attracting or retaining health professionals, it could alter the projections considerably. Current levels of turnover are high, particularly in the younger age groups. This churn is costly and results in the NT needing to attract ever larger numbers of health professionals each year to maintain and expand its workforce. There are also indirect effects from mobility, both positive and negative, through changes it can make to the age structure of the health workforce.

Graduates were an important inflow in the models. They contributed to growth in size of the workforce and they have the potential to contribute more years of work than health professionals that migrate to the NT later in life. Local graduates also offer the advantage of being more likely to stay in the NT and they may be better prepared for the unique work environment than health professionals from other states and countries. A potential risk for the NT was the projected increase in the number of local nursing graduates. Their number may exceed the places available on DHF's graduate nurse program if this is not expanded, leaving some graduates to find alternative pathways into the workforce or consider interstate positions or other careers. Regardless of where they come from, the entry of more graduates than are presently taken is needed if supply is to exceed demand.

The modelling identified key pressure points in the requirement for medical and nursing services. The most pressure was expected to come from elderly patients whose collective needs were expected to more than double over the projection period. In terms of specialty areas, the increase in demand was expected to be highest for cardiology, neurology and oncology services. Across the regions, Darwin was expected to experience the strongest growth in the demand for nursing services, followed by East Arnhem and Alice Springs. Medical practitioners would also be needed to support remote services in those regions.

This growth in demand represents the minimum workforce requirement to maintain the health of the population at current levels. Disability adjusted life-years (DALYs) were used as the measure of population health and estimates were available for both Australia and the NT. When the 2006 workforce was benchmarked against the national average, it showed that there were a third fewer medical practitioners and nurses in the NT to treat every 100 DALYs in the population than there were nationally without considering the loss in efficiency from servicing small, remote communities. This differential is likely to increase the pressure on NT health professionals and give Territorians less access to services.

It is hoped that the projections will facilitate more sophisticated discussion in the NT about the demand and supply of health professionals by highlighting minimum growth requirements, key areas of vulnerability in supply, indirect effects from workforce mobility and emerging issues such as the placement of graduates. The modelling was, however, limited by the integrity and availability of current data sources. Most notably, there was no reliable source to estimate the NT health workforce. Census data was used, but it can only be updated every five years and it only captures resident health professionals. Better information on the current NT health workforce including graduates could enhance the modelling. The modelling would also benefit from further research on exits and re-entries into the health workforce and measures of need that can capture the workforce requirements associated with the prevention of disease and injury.

Introduction

With a substantial proportion of health workforce nearing retirement age and demand for health services from an ageing Australian population increasing, there is much concern about whether there will be sufficient health professionals to meet the future need for their services.[1,2] In the Northern Territory (NT), these issues are compounded by high mobility in the workforce, the poor health of Indigenous people and the need to provide services to remote communities.[3,4] In the face of these pressures, understanding workforce requirements and the capacity to meet those requirements will be important for ensuring that service provision can be sustained into the future.

Forecasting the supply of, and demand for, health professionals has a substantial history, beginning in the United States of America. In 1976, the Graduate Medical National Advisory Committee was tasked with advising on the need for medical practitioners and produced estimates of supply and demand for 1990 and 2000.[5] In the past decade, the Health Resources and Services Administration has modelled the supply and demand of medical practitioners, nurses and pharmacists and made its methods available for use by others.[6-8] Other researchers built on these models[5] and created alternative approaches (e.g., Birch et al.,[9] Scheffler et al.,[10] Lin et al.[11]). Early models tended to predict that the supply of physicians would exceed requirements, but more recent models have tended to predict that there will be shortages of health professionals.[10] Although this change could reflect policy that constrained supply in response to the predictions of early models, it is also likely to reflect improvements in the variables, data, assumptions and approaches used in more recent models.

In Australia, a substantial amount of workforce modelling has occurred over the past two decades under the sponsorship of the Australian Health Workforce Advisory Committee,[12] state and federal governments (e.g., Department of Human Services,[13] Access Economics[14]) and other bodies such as the Pharmacy Guild of Australia,[15] and the Council of Deans of Nursing and Midwifery.[16] Most recently, the National Health Workforce Taskforce (NHWT) has been tasked with development of projections of supply and demand for the medical, nursing, dental and allied health workforces.[17] A key purpose of this modelling has been to guide policy and funding on the educational and training places required to maintain the supply of health professionals.[17] Despite large increases in Australian medical school places since 2000, recent models indicate that future requirements for medical practitioners will still exceed local supply and Australia will remain dependent on overseas trained practitioners to make up the shortfall.[18] Shortfalls in the nursing workforce are also expected without continued expansion of university places.[19]

Current modelling by the NHWT applied a standard methodology and data sources across the states and territories to estimate the requirements for, and supply of, health professionals. This approach facilitated the aggregation of jurisdictional projections into a national estimate, but limited the inclusion of circumstances unique to each jurisdiction. In particular, the modelling did not effectively capture the high level of mobility in the NT workforce and unmet need in the NT Indigenous population. The modelling also used data sources that poorly estimated the size and characteristics of the current NT workforce and future graduate streams.

The NT Health Workforce Modelling Project, established by the Strategic Workforce Committee of the Department of Health and Families (DHF), sought to inform workforce planning in the NT by modelling the future requirements for, and supply of, health professionals in the NT. The project aimed to identify the best approach to

modelling that could incorporate variables of specific importance to the NT. The project's purpose was to produce projections for the medical and nursing workforces and to compare workforce levels in the NT with the national average. Ethical approval for the project was obtained from the Human Research Ethics Committee of the NT Department of Health and Families and Menzies School of Health Research.

This report presents a summary of the project's outcomes. More detailed information on the project's outcomes and technical information on the models can be found in two accompanying reports – *Health Workforce Modelling, Northern Territory, Technical Report for the Medical Workforce Model* and *Health Workforce Modelling, Northern Territory, Technical Report for the Nursing Workforce Model*. These reports are available through the DHF website.[a]

This report is structured as follows: first, the approach for modelling the NT health workforce is discussed. Second, the data parameters of the model are outlined and issues with current data sources noted. Third, baseline projections of demand and supply are presented for the medical and nursing workforces and key influences on the projections discussed. Pressure points with regard to specialty, subgroups within the population and regional areas are then investigated and the level of the current NT health workforce compared with the national average. Finally, the implications of the modelling are discussed and summarised.

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[a] At http://www.health.nt.gov.au/Publications/Health_Gains_Planning_Publications/index.aspx

Method

NT modelling approach

The best approach for modelling the future requirements (demand) for, and supply of, health professionals in the NT was identified by evaluating the strengths and weaknesses of prior modelling approaches in terms of their ability to incorporate circumstances specific to the NT and provide robust projections. The full review of the models is provided as an appendix to this report (Appendix 1). The review determined that different approaches were required for the demand and supply modules of the model. For the supply module, the predominant method used in previous models was the stock and flow approach and this was followed in the NT model. The stock and flow approach identifies the size and activity of the current workforce (stock), sources of inflows and outflows from the stock, and important trends or influences on the stock and flows. It allowed inclusion of the key flows of importance to the NT and use of the most relevant NT data sources. This approach did, however, have high data requirements and the results were dependent on the quality of the data available.

There were more options for the approach to modelling demand, but each had strengths and weaknesses.[b] A needs-based approach, which uses the health of the population as the basis for determining workforce requirements,[20] was determined as the best available approach for capturing the unmet needs of the Indigenous population and suitable data was available for use in the model. The limitations of this approach were its inability to reflect the impact of substitution between occupational groups and allow for infrastructure, funding and other constraints on service provision.
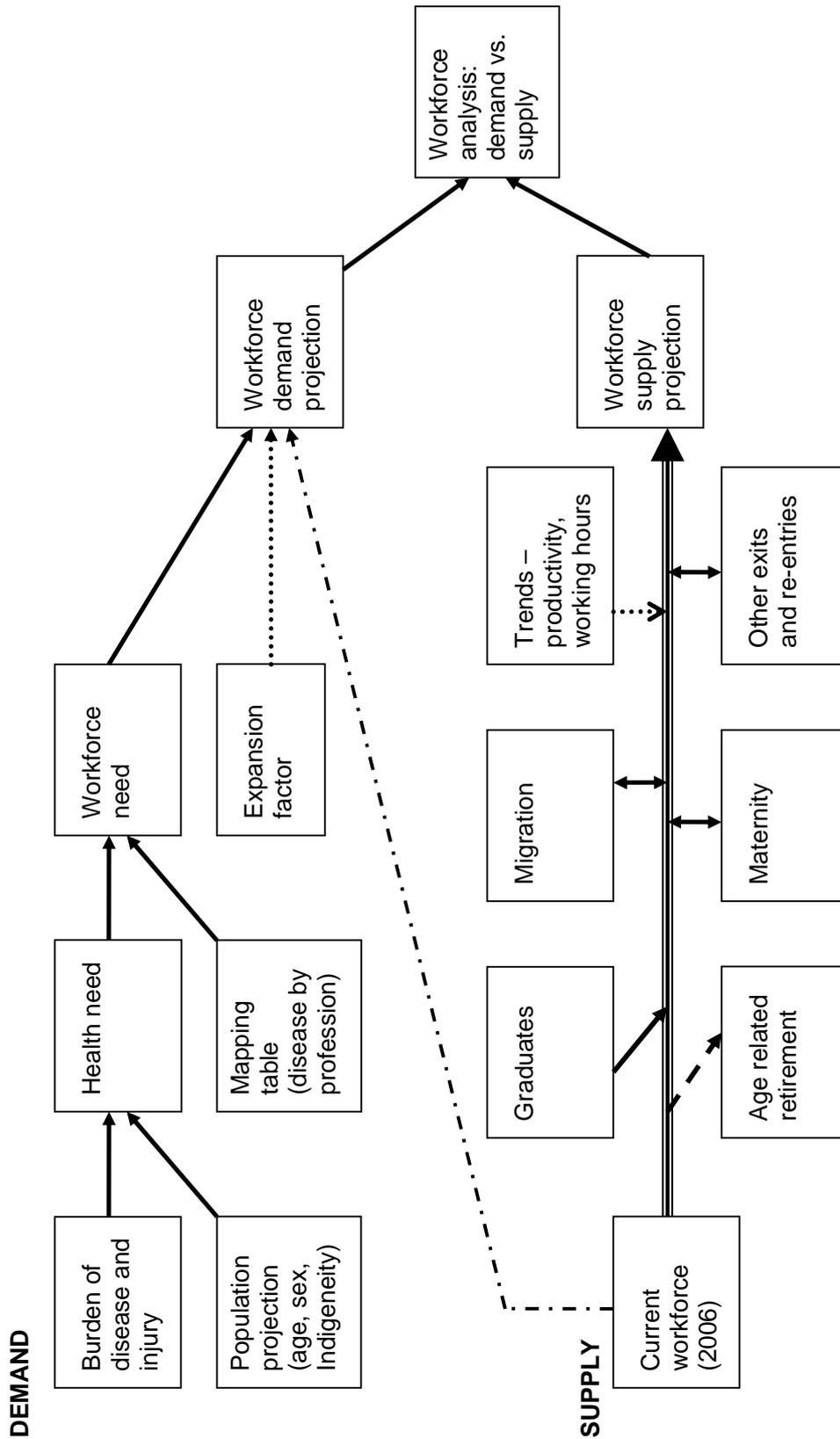
Data parameters and sources

Two workforce models were developed: the NT medical workforce model (the medical model) projects the supply and demand of medical practitioners and the NT nursing workforce model (the nursing model) projects the supply and demand of registered nurses and midwives (nurses). Figure 1 shows the data parameters for each module of the models. The sources of data differed between the medical and nursing models for some parameters. In particular, the estimation of nursing graduates was more complex than for medical practitioners and necessitated the inclusion of an additional element (the graduate component) in the supply module of the nursing model. The models were populated using best available data at the time of their development.

Demand module data parameters

Table 1 shows the data parameters and data sources for the demand modules of the medical and nursing models. The population parameter provided an estimate of the population in each year of the projection period. It was segmented into 36 sub-groups to capture differences in the nature and occurrence of disease and injury by age, gender and Indigenous status.[21,22] The data source for this parameter was NT Government/Charles Darwin University (NTG/CDU) projections of the NT population,

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[b] The literature included needs-based, utilisation-based, effective demand, effective infrastructure, models of care, macro-economic and benchmarking models. Further analysis is provided in the report reviewing these models (Appendix 1).

Figure 1 NT workforce model

based on data compiled by the Australian Bureau of Statistics (ABS) on population numbers, migration, births and deaths.

Table 1 Parameters and data sources for the demand module of the NT health workforce models

Parameter	Data source (medical and nursing models)
Population	NT Government/Charles Darwin University estimates based on ABS data.
Health need	Zhao Y, You J, Guthridge S. Burden of Disease and Injury in the Northern Territory 1999-2003. Darwin: DHF, 2009.
Medical/nursing weights	Department of Health and Ageing. National Hospital Cost Data Collection, Cost Weights for Primary AR-DRG Version 5.1, Round 11 (2006-07), Northern Territory.
2006 workforce	Number parameter from supply module.
Expansion factor	User defined.

The health need parameter measured the extent of ill health in the NT population. Disability adjusted life years (DALYs), which incorporate both fatal (years of life lost due to premature mortality) and non-fatal outcomes ('healthy' years lost due to disability) were used as the data source.[23] This source provided estimates of the level of ill-health for the 36 population sub-groups across 190 categories of disease and injury. The categories were condensed into 185 groups (burden of disease and injury [BoD] groups) for the workforce models.

To translate health need into a workforce requirement, the necessary treatments for the BoD groups were mapped to hospital treatments using Australian Refined Diagnosis Related Groups (AR-DRGs). Estimates of the medical (medical weights) and nursing resources (nursing weights) required to treat an AR-DRG were based on costings of NT hospital separations from the National Hospital Costs Data Collection (Round 11; 2006-07).

A starting workforce was required to translate the workforce requirement into a numbers of health professionals. The starting workforce was set at the headcount number of medical practitioners or nurses from the supply module to reflect the total number of health professionals providing services regardless of their provision of hours. The last parameter in the demand module was an expansion factor, which provided the capacity for workforce planners to increase the requirement for medical practitioners or nurses by a specified amount (to meet expected policy changes, technological advancements or other goals and developments). The expansion factor was set at zero (no expansion) in both models.

Key limitations with the data sources for the demand module were:

- The DALY only captures ill health; no assessment is made of the resources needed to achieve the present levels of incidence (prevention).

- The burden of disease was held constant over the projection period. No allowance was made for changes in the incidence of disease and injury even though the occurrence of some chronic conditions may be increasing.

- BoD studies only occur periodically, limiting the ability to update the module.

- The workforce requirement was based on hospital services, which may not be reflective of requirements in other sectors such as primary health and aged care.

Supply module data parameters

Table 2 shows the data parameters and data sources for the supply modules of the medical and nursing models. A profile of the current medical and nursing workforces (the stock) segmented by age and sex was required to project workforce supply. The number, age and sex parameters formed this initial stock, which was then moved forward over time based on inflows and outflows from newly trained professionals (graduates), retirements, maternity, migration and other factors. ABS census data from the AIHW's Health and Community Services Labour Force (HCSLF) publication was used for working population component of the stock.[1] AIHW's Medical Labour Force Survey and Nursing Labour Force Census (AIHW labour force surveys), which gather demographic and labour force information from health professionals, were used to estimate the non-working population.[24,25]

Table 2 Parameters and data sources for the supply module of the NT health workforce models

Parameter	Data source (medical and nursing models except where indicated separately)
Number (headcount)	Australian Institute of Health and Welfare Health and Community Services Labour Force 2006 (AIHW HCSLF); AIHW labour force surveys.
Age	AIHW HCSLF.
Sex	AIHW HCSLF.
Average working hours	AIHW labour force surveys.
Full-time equivalent benchmark	*Medical*: Medical Officers (NT Public Sector) Workplace Agreement 2008-2010. *Nursing*: NT Public Sector Nurses' 2008 – 2011 Union Collective Agreement.
Graduates	*Medical:* DHF, Intern numbers (Royal Darwin and Alice Springs hospitals), unpublished data. Australian Government Department of Education, Employment and Workplace Relations (DEEWR), Students 2006 [full year]: selected higher education statistics. *Nursing:* Refer Table 3
Immigration	Australian Bureau of Statistics (ABS), unpublished census data (multiple years), obtained by request, 2007
Emigration	ABS, unpublished census data (multiple years), obtained by request, 2007
Retirement exits	ABS, Retirement and retirement intentions survey, Australia, Jul 2006 to Jun 2007, Cat no. 6238.0
Maternity exits and re-entry	Health Gains Planning (HGP) NT Midwives Collection, Mothers and Babies, 2005; HGP population estimates 2005, unpublished data based on ABS data; ABS, Australian Social Trends 2007, Cat no. 4102.0, Maternity Leave Arrangements.
Mortality and morbidity	HGP, Fact sheet: Mortality in the NT, 2006. DHF, exit interview data, unpublished.

The average working hours parameter accounted for differences by age and sex in actual hours worked. The AIHW labour force surveys were the data source for this parameter and trends in average working hours over time incorporated into this

variable. The Full-Time Equivalent (FTE) benchmark is the average hours that a medical practitioner or nurse would be expected to work in a full-time position. This information was used to count the number of FTE positions that were supplied in each year of the projection period and to determine the additional hours provided by the workforce. The FTE benchmark was set at 38 hours per week, which was consistent with the standard hours of a full-time public sector medical practitioner or nurse as DHF is the primary employer of health professionals in the NT.[26,27]

Interstate and international movements are key flows to and from the NT workforce. ABS census data on present and past place of usual residency by professional group was used to calculate immigration and emigration rates.[4] This source captured most forms of migration with the exception of international emigration and rates could be calculated at a suitable level of detail for the supply module. The average over five censuses was used so that the estimates would be less sensitive to random fluctuations in any census year. Emigration rates were applied to the workforce of the previous period to derive the starting workforce for the following period and immigration rates were applied to the workforce in each period after all other flows had been accounted for.

Ageing is a key concern with much of the health workforce being over 50 years of age.[24] The ABS Retirement and Retirement Intentions Survey was used to determine retirement rates for the supply module.[28] Rates were based on the intentions of the general population and were the same for females and males. No age related retirements were assumed to occur below 50 years of age for medical practitioners and below 45 years of age for nurses. The age by which all health professionals had retired differed. Male medical practitioners were assumed to have all retired by the end of their 80th year and female practitioners by the end of their 70th year, to reflect the tendency of some medical practitioners, particularly males, to continue to work well past the standard retirement age of 65.[24] Nurses were assumed to have all retired by the end of their 70th year as there were relatively few working past this point.[1]

Maternity absences were calculated based on the proportion of women likely to have a birth, the proportion of birthing women likely to take leave for maternity, the average length of maternity leave and the proportion of women who return at the end of their leave. Non-Indigenous data for the general population were used (the data sources are indicated in Table 2). The proportion of women who take leave was 73% and the average duration of leave was 34 weeks. No data were available on the proportion of women returning from leave so this was set at one (i.e., all return). No allowance was made for paternity leave by male health professionals.

The capacity to include exits due to mortality and morbidity was incorporated in the supply module, but mortality data and DHF exit interview data for nurses did not indicate that these exits occurred to such an extent that their inclusion would substantially refine the projection.[29,30] More generally, the exit interview data suggested that about 2.9% of the nursing stock would have been likely to leave due to study, poor work environment and other reasons.[30] The responses to the AIHW labour force surveys indicated that there are also nurses re-entering the workforce after an absence although no detail was available on the reason for their absence. In 2005, about 1.3% of non-working nurses in Australia were seeking to return to work in nursing.[24] These rates were applied across all age groups in the supply module of the nursing model to account for the occurrence of other departures and re-entries in that workforce. Similar data was not available for medical practitioners so no allowance was made for morbidity, mortality and other exits and re-entries in the medical model.

The output (productivity) of health professionals may be influenced by factors such as change in the acuity of cases, technology, work practices or the stability of the

workforce. The productivity parameter adjusts for these impacts. Crude measures of productivity based on separations and FTE staff drawn from DHF's annual reports did not support inclusion of an adjustment so this parameter was set at 1 (i.e., no change in productivity).

Key limitations with the data sources for the supply module were:

- Census data is only available every five years, limiting the ability to update the module.

- Census data may omit health professionals who provide visiting services to the NT; those that were not working in a medicine or nursing role during the census; and those working in medicine or nursing as a secondary role.[4]

- Low response rates to the AIHW labour force surveys in the NT mean that this source is not presently suitable as an alternative to the census for the stock.

- Exit interview data was only available for nurses and was incomplete as interviews are not compulsory.

- Maternity exits did not account for women who exit the workforce to care for older children.

Graduate projections

The NT does not yet have a medical school, but there are students studying through the NT Clinical School who complete their placements in the NT. A medical school will be established in the NT; however, data is not yet available on the likely flow and profile of graduates.[31] Royal Darwin and Alice Springs hospitals take interns (medical practitioners in their first postgraduate year). The actual number of interns in each year to 2009 was included in the model then numbers were held constant over subsequent years in the projection period. Graduates were assumed to be under 30 years of age and that females comprised 55.6% of graduates based on the current gender mix of Australian medical students.[32]

For nursing, two institutions provide undergraduate nursing courses in the NT – Charles Darwin University (CDU) and the Batchelor Institute of Indigenous Tertiary Education (Batchelor). In 2006, 357 students commenced studies in nursing programs with these institutions – 30 at Batchelor and 327 at CDU.[33] Although the majority of Batchelor's students were expected to be NT residents,[34] most of CDU's students were based interstate[35] and are unlikely to move to the NT at the completion of their study. This situation means that there is not a simple relationship between the number of university places and the expected flow of graduates into the NT nursing workforce.

A separate element (the graduate component) was added to the supply module in the nursing model to project the expected flow of local nursing graduates. The data parameters and data sources for the graduate component of the nursing supply module are shown in Table 3. The numbers of local nursing graduates were projected based on:

- Available tertiary places estimated from the numbers of commencing students in 2006 and 2007[33] and new Commonwealth supported nursing places on tertiary courses.[32]

- Fill rates (of available places) based on advice from CDU and Batchelor[34,35] and allowing for a reduction in the fill rate after 2008 due to increased competition and difficulties obtaining clinical placements for students.[36]

- Attrition during the course.[37]

- The proportion of part-time and local (Australians, residing in the NT) students.[35]
- The CDU age/sex profile for local students.[35]

Table 3 Parameters and data sources for the graduate component of the supply module of the nursing model

Parameter	Data source
Available tertiary places	Australian Government, Department of Education, Science and Training (DEST). Students 2007 [full-year]: selected higher education statistics, nursing & prior years. DEEWR. New Commonwealth supported NT nursing place targets.
Proportion of places filled	DEST. Applications, offers, acceptances and unmet demand time series, 2001-2008.
Student attrition rate	Gaynor et al. (2008)[37]
Proportion part-time students	Charles Darwin University (CDU), unpublished data.
Proportion of local students	CDU, unpublished data.
Course duration	CDU, standard completion timeframe
Actual local graduates	CDU, unpublished data.
Proportion female graduates	CDU, unpublished data.
Graduate age	CDU, unpublished data.
DHF graduate nurses	DHF, graduate nurse program, unpublished data.

The projection of local nursing graduates was likely to be conservative as it excluded growth in full-fee paying students and places sponsored by entities other than the Australian Government. The projection could be improved by the collection of demographic data and other characteristics of graduates entering the DHF workforce. It would also be useful to examine the length of stay in the workforce of local graduates compared with interstate graduates and other nurses that migrate to the NT.

Results

Workforce analysis: demand versus supply

Medical workforce

The medical model projects the requirements for, and supply of, medical practitioners over the period 2006 to 2022. Figure 2 presents the baseline projections of demand and supply for the medical workforce. Over the projection period, the requirement for medical practitioners was projected to increase by 49.9% from 559 practitioners in 2006 to 838 practitioners in 2022. By 2022, the key contributors to the need for medical services were: ischaemic heart disease (IHD); diabetes; chronic obstructive pulmonary disease (COPD); breast cancer and vascular conditions (stroke, aortic aneurysm). Together, they accounted for at least a third of medical requirements.

Figure 2 Demand for and supply of NT medical practitioners, 2006 to 2022
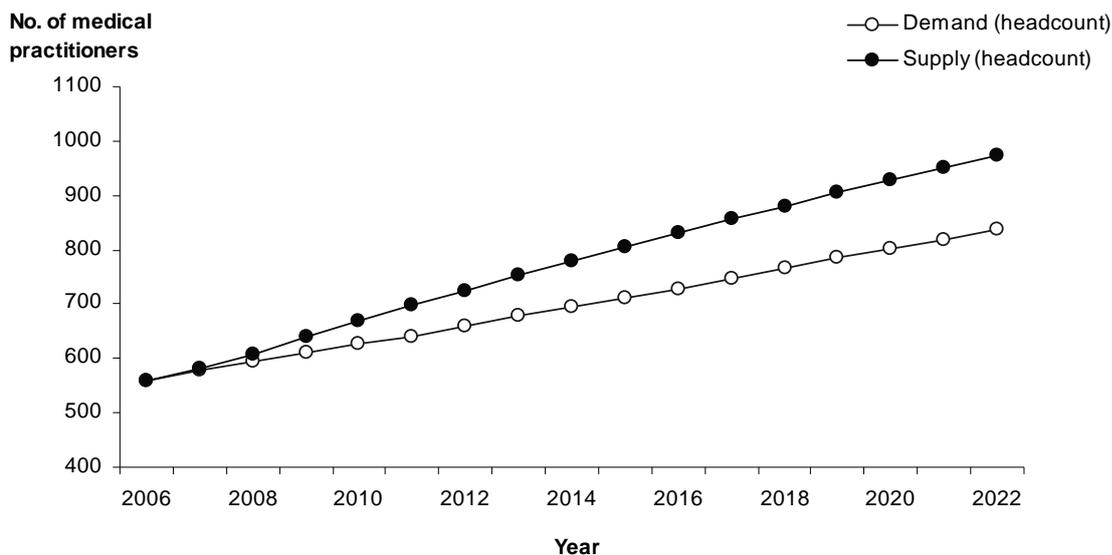
The supply of medical practitioners was projected to increase by an even greater amount – 74.4% (from 559 to 975 practitioners) and to exceed the growth in requirements. Headcount numbers of medical practitioners exceeded FTE numbers and the gap widened over the projection period from 13 FTE in 2006 to 31 FTE in 2022. There was also a sizeable reduction (41.3%) in the additional supply of labour from the workforce (hours in excess of FTE benchmark). The reduction in hours worked arose from an anticipated reduction in the average working hours of male practitioners over the projection period (1.0% per annum based on national trends) and an increase in the proportion of female and older practitioners who tend to work shorter hours. The proportion of females in the NT medical workforce increased over the projection period from 45.3% in 2006 to 48.7% in 2022. The increase was largely due to the assumption that more than half of the graduate intake would be female.

Figure 3 shows the change in the age distribution of the medical workforce over the projection period. The key area of change was the increase in practitioners aged over 60 years with their proportion increasing from 6.6% in 2006 to 15.9% in 2022. The

ageing of the workforce and positive net migration drove the increase in this age group. In contrast, large declines occurred in the 40-49 age group. Initially, this group comprised the largest proportion of the workforce (31.1%), but by 2022, it accounted for only 18.4% of the workforce. The reduction was due to ageing of the initial population and migration losses. Although the proportion of the 30-39 age group grew, its impact on the overall growth of the workforce was constrained by high turnover with large migration in-flows being matched by equally large out-flows.

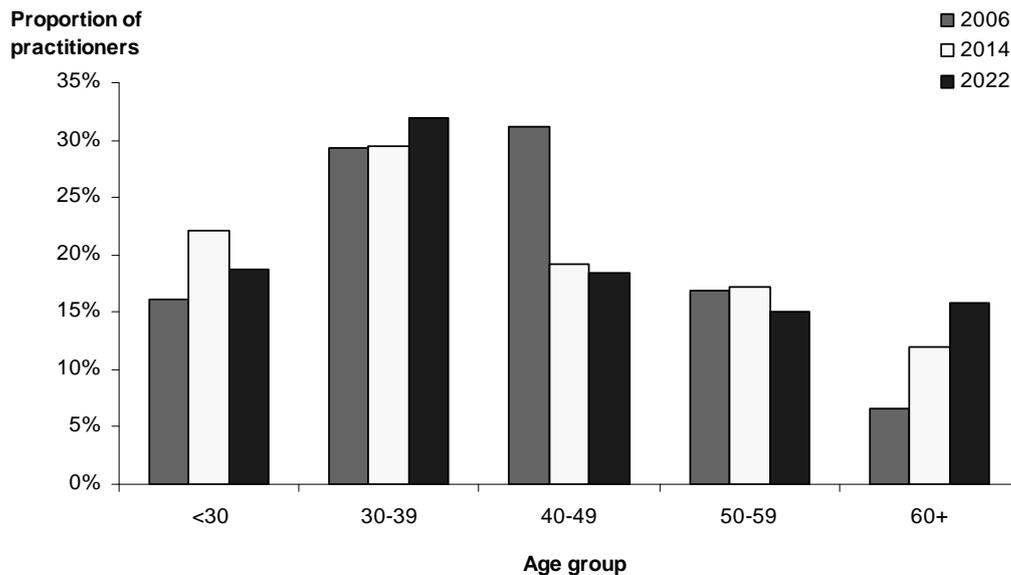**Figure 3 Age distribution of NT medical workforce, selected years: 2006, 2014 and 2022**

Figure 4 presents alternative scenarios that emphasise key areas of uncertainty in the baseline projections. There has been substantial growth in separations in the NT since 2000-01 and this was closely associated with an expansion in the DHF medical workforce.[38] Despite the increase in services, there is still a substantial health gap between Indigenous and non-Indigenous Territorians.[23] The needs approach is unlikely to reduce this gap as it only accounted for the additional health needs arising from population change (i.e., growth comprised of the needs of additional people and change associated with ageing). To bridge the health gap or improve the health of all Territorians, further expansion in services and thus, workforce would be required. As shown in Figure 4, continuing to increase hospital separations in accordance with past trends would mean that 1116 medical practitioners were required in 2022 – 33.2% more than estimated using the needs approach.[38]

If the trends projection were to better represent future requirements than the needs projection, it would mean that the supply of medical practitioners would exceed demand until 2015 when circumstances would reverse and by 2022 there would be a shortfall of 12.6% in the medical workforce. Other demand-side risks include greater than anticipated population growth and an increase in the incidence of chronic disease. These factors had a much lesser impact on the projected demand for medical practitioners, for example, NTG/CDU's higher estimate of the NT population (8.1% more due to increased migration) had only half the impact on demand (4.0% increase) while a notional 5.0% rise in the incidence of chronic disease increased demand by 1.2%.

Figure 4 Alternative scenarios of demand and supply, NT medical workforce, 2006 to 2022
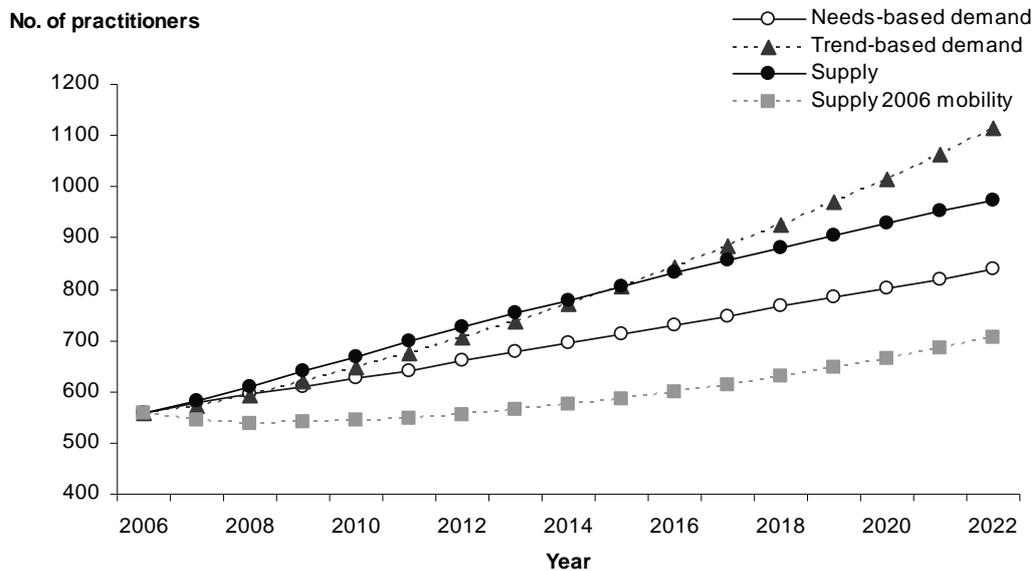
On the supply side, the projection was very sensitive to the mobility of the medical workforce and this is shown in Figure 4 by using the 2006 Census trends. In 2006, net migration was negative except for male practitioners aged 40 years and over.[39] If these rates were indicative of future patterns of migration, it would mean that in 2022 there could be 27.5% fewer medical practitioners than in the baseline projection and a shortfall of 15.7% between demand and supply. It would also alter the structure of the workforce by substantially increasing the proportion of the workforce aged over 50. This change would leave the NT vulnerable to older practitioners' decisions on the amount of time they will spend in the workforce.

The other key influence on projected supply, but not illustrated in Figure 4, was the flow of medical graduates. The number of Australian graduates is predicted to increase substantially in coming years (81.3% between 2005 and 2012)[40] and combined with the proposed NT medical school, it presents an opportunity for the NT to increase its graduate intake. A 50.0% increase in the annual number of graduates (from 28 to 42) from 2012 onward increased the size of the medical workforce in 2022 by 22.7% compared with the baseline projection. If they could be convinced to stay in the NT then it could have an even greater impact on growth and rebalance the age structure of the workforce.

Nursing workforce

As with the medical model, the nursing model projected the requirements for, and supply of, nursing professionals over the period 2006 to 2022 and Figure 5 presents the baseline projections from the model. Over the projection period, the requirement for nurses was projected to increase by 50.9% from 1888 nurses in 2006 to 2849 nurses in 2022. As for medical practitioners, diabetes, IHD and COPD were key contributors to the requirement for services. Lung cancer and stroke were the other major contributors and together the top five accounted for 37.0% of the nursing requirement in 2022.

The growth in the supply of nurses was projected to be lower than the growth in requirements in the early years of the projection period. The shortfall widened to 3.4% of requirements in 2010 then diminished as an increased flow of local graduates provided a steady boost to the workforce. From 2015 onward, the supply of nurses was

projected to exceed demand and the gap widened over the remainder of the projection period. By 2022, there would be 9.7% more nurses than were needed to meet growth in demand. Headcount numbers of nurses exceeded the FTE supplied at the beginning of the projection period and this gap widened from 221 FTE in 2006 to 336 FTE in 2022.

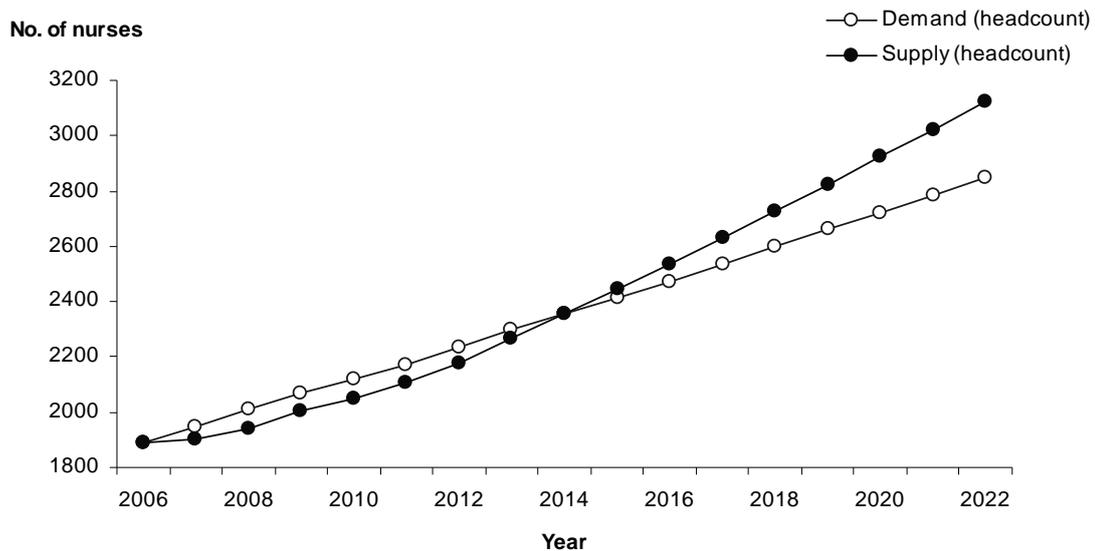**Figure 5 Demand for and supply of NT nurses, 2006 to 2022**

Figure 6 shows the change in the age distribution of the workforce over the projection period. The key area of change was the increase in nurses aged less than 40 years compared with those over 40 years. In 2006, 44.4% of the workforce was aged under 40, but by 2022 it had increased to 64.1%. This change was driven by the inflow of graduate nurses who were mostly in younger age groups; positive net migration in the 30-39 year group; and the exit from the workforce of older workers due to retirement and emigration. The proportion of males in the nursing workforce was expected to increase from 10.9% in 2006 to 13.4% in 2022 and this was driven by the expected gender profile of graduates.

Figure 7 shows the projected number of undergraduate places, local graduates and places on DHF's graduate nurse program. Despite the large number of tertiary places in NT institutions, a maximum of 130 local students per annum were expected to graduate during the projection period. The number of local graduates was projected to exceed the number of places available on the DHF graduate nurse program in 2010. Without an increase in the places on the program, up to 40 graduates per annum could be left to seek entry to the workplace through other avenues.

Figure 6 Age distribution of NT nursing workforce, selected years: 2006, 2014 and 2022
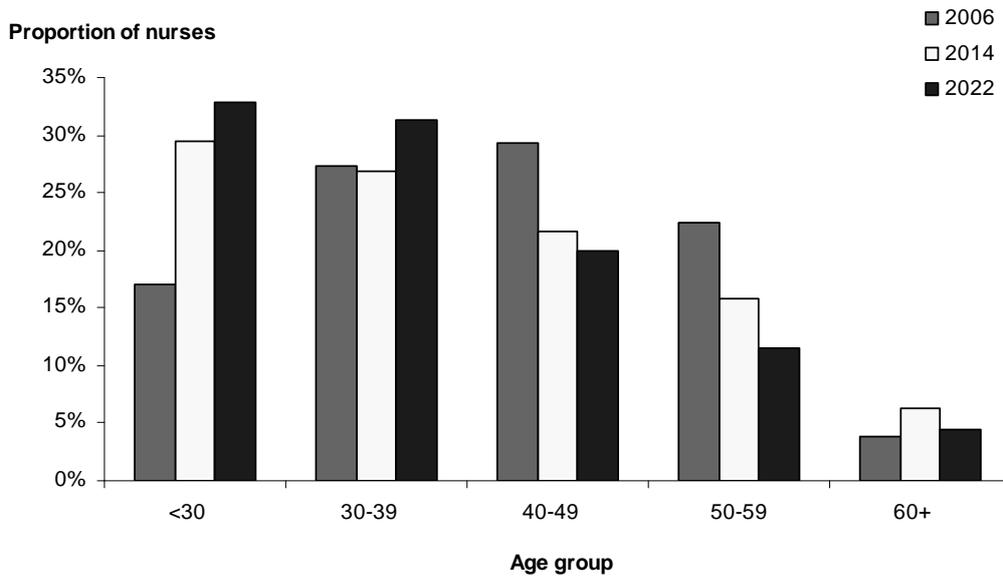
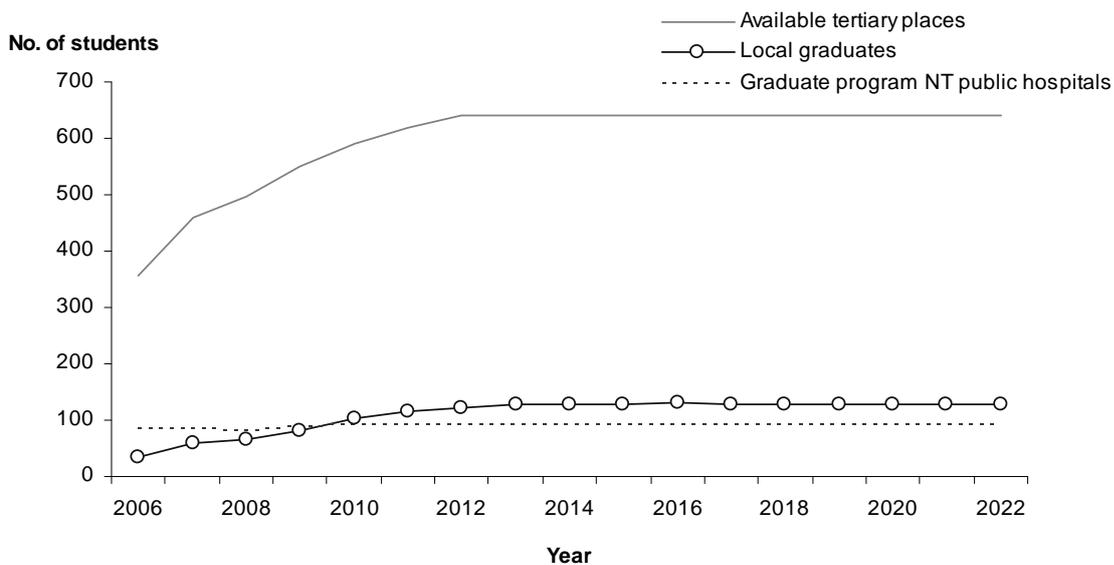**Figure 7 Local nursing graduates, 2006 to 2022**

Figure 8 presents alternative scenarios that emphasise key areas of uncertainty in the baseline projections. As noted with the medical model, higher growth in the workforce may be desirable to reduce health gaps and improve the health of the population. If past rates of expansion in separations continue to occur, 3440 nurses would be required in 2022 – 20.7% more than estimated using than the needs approach. A supply scenario that elicited a similar growth projection would be to have no net separations other than for migration and maternity. This scenario would require exits due to other factors to be off-set by an equal number of re-entries or for nurses to shift between part-time, casual and full-time employment rather than exit altogether.

Figure 8 Alternative scenarios of demand and supply, NT nursing workforce, 2006 to 2022
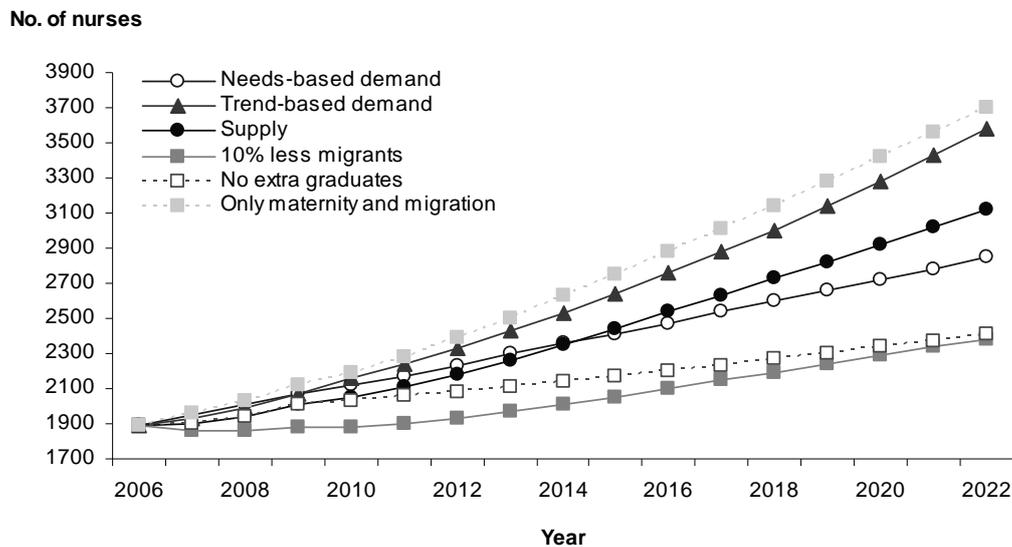
Two other key issues for the NT are the mobility of the workforce and graduate numbers. Any reduction in immigration without an equivalent reduction in emigration may mean that supply does not match demand. For example, a 10.0% decrease in immigration had more than twice the impact on the size of the workforce, reducing the number of nurses in 2022 by 23.7%. Such a situation could occur if competition for nurses increases from other states and countries. The projections will be equally sensitive to changes in emigration rates with decreases enabling greater growth in the workforce and/or reducing the need to attract interstate or overseas nurses. Increases would, however, have the opposite effect.

A final scenario shown in Figure 8 is the effect of holding graduate numbers constant at the current level of places on the DHF graduate nurse program. It meant that the growth in supply was insufficient to meet the growth in needs across the entire projection period. Such a situation could occur if a lesser number of local students undertake nursing studies than was projected or excess local graduates are unable to find alternative pathways into the NT workforce.

Pressure point analysis

The projected demand for medical and nursing services does not fall evenly across diseases or groups within the population. To examine the relative impact on different areas, 'Specialties' were identified by either the relevant population (Paediatrics – age 14 years and under; Geriatrics – age 65 years and over; Aboriginal Health) or allocation of BoD groups to a disease-based specialty areas based on the judgement of a health professional experienced in data analysis.

As shown in Figure 9, the greatest growth was expected to occur in servicing the needs of elderly people. Demand for medical services from this group more than doubled over the projection period. This growth means that health services will be treating much greater numbers of elderly patients in future years and their needs may be more complex due to their age. The major medical service requirements of the over 65 year age group were for heart disease, COPD, diabetes, dementia and lung cancer. Demand from Indigenous Territorians was expected to grow by 50.0% over the

projection period. As with the elderly, heart disease, diabetes and COPD were key drivers of demand for Indigenous Territorians, but their other major requirements – renal disease and road traffic accidents – differed. In terms of specific disease groups, the key pressure points for medical services will be the increase in demand for cardiology (65.4%), oncology (60.1%), internal medicine (55.3%), neurology (54.9%) and rehabilitation (53.6%) services.

Figure 9 Growth in medical demand by specialty, selected years relative to base year of 2006
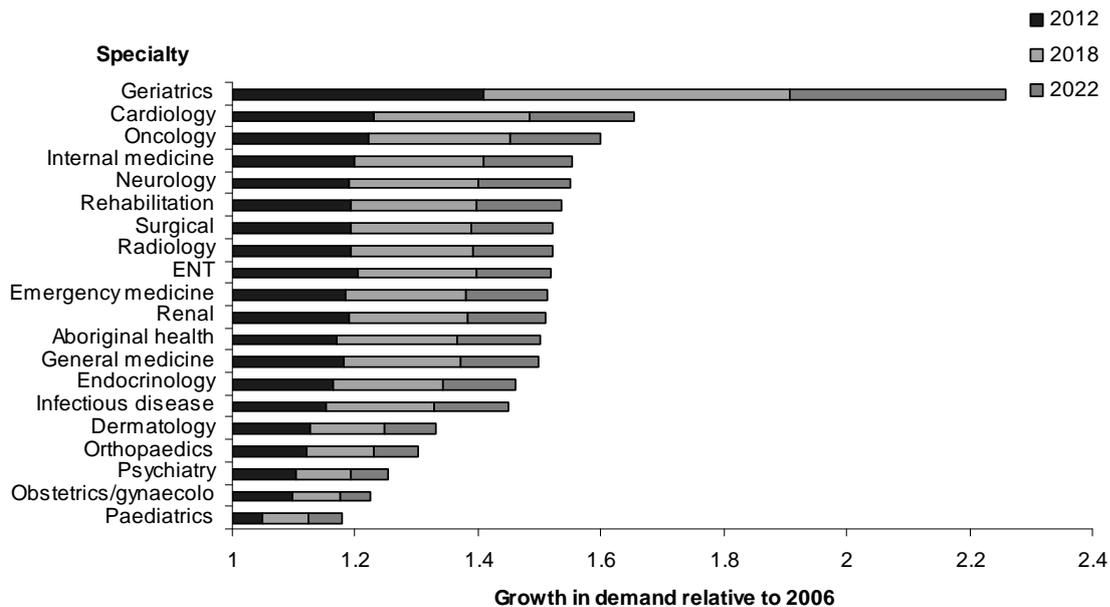
Note: 2006 is the base year and not shown

For nursing, pressure points were similar to those for medical services with the greatest growth in need coming from the elderly. In terms of specific disease groups, the key pressure points for nursing services were expected to be the increase in demand for cardiology (65.5%), neurology (62.7%), oncology (62.2%), radiology (54.4%) and internal medicine (53.6%).

The supply of medical practitioners and nurses to work in speciality areas was not projected due to the lack of a sound data source. The AIHW labour force surveys gather information on principal areas of practice and specialty areas, but the low response rate to the surveys mean that many health professionals may not be captured and estimates based on those who did respond may be biased. Further, the small numbers of specialists and high mobility of the health workforce means that any data are unlikely to be stable.

Regional analysis: nursing

The NT needs to provide health services to a small population dispersed over a large geographic area. Presently, hospitals and other key health services (GPs, aged care services) tend to be located in the largest, most accessible population centres, namely, Alice Springs, Darwin, Katherine, Nhulunbuy and Tennant Creek. Beyond these main urban areas, nurses operate health clinics in small, remote communities complemented by visiting services from medical practitioners.[41] A regional analysis was conducted to

show where the future growth in the nursing requirements was expected to occur. This analysis also implies where additional support services by medical practitioners would be needed.

Figure 10 shows the demand for nursing services for six regions based on statistical reporting areas. A map of the regions is at Appendix 2. The population forecasts by region were only available up to 2021 so the analysis was restricted to that year. Between 2006 and 2021, the greatest growth in the requirement for nursing services was expected from residents in Darwin, Palmerston and nearby settlements. Their nursing requirements were expected to be 60.0% higher in 2021 than in 2006. The next greatest increase was expected in East Arnhem (53.3%). Growth was expected to be lowest in the Katherine region, but the requirement for nursing services from residents in this area were still expected to be 26.7% higher in 2021 than in 2006.

Figure 10 Growth in nursing demand by region, selected years relative to base year of 2006
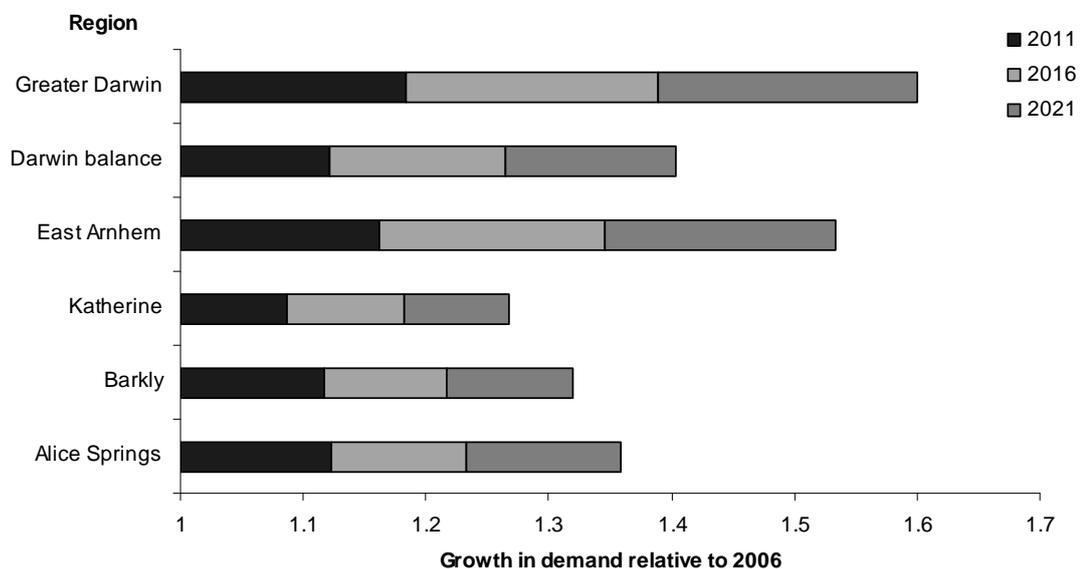
Note: 2006 is the base year and not shown

Benchmark analysis

A key issue for the NT is the adequacy of the current health workforce. To investigate this matter, the NT workforce was compared with the national average. The number of health professionals per 1000 population was used as an indicator of availability and the number of health professionals per 100 disability adjusted life years was used as a measure of the workforce available to treat the amount of disease and injury in the population.

As shown in Table 4, the comparison revealed that in 2006 the numbers of health professionals per 1000 population in the NT were similar to the national average. Numbers of nurses were slightly less than the national average, but this was offset by higher numbers of Aboriginal health workers (AHWs). When, however, health need was considered, circumstances changed considerably. The burden of disease and injury in the NT was 50% more than in the nation as a whole (198.6 age standardised DALYs per 1000 population compared with 132.4 nationally). When matched to the number of health professionals, the NT had at least a third fewer medical practitioners

and nurses to treat every 100 DALYs in the population than nationally. The NT has more AHWs, but as their number is relatively small it does not substantially affect the total number of health professionals per 100 DALYs.

Further, these ratios do not account for the additional demand associated with the high levels of comorbidity in Indigenous patients and the loss in efficiency associated with servicing small, remote communities. These losses include time spent in travel, minimum staffing requirements and absences or temporary (less efficient) staff for leave, professional development and other absences. The national figures should, however, be interpreted with caution as it is not clear that they represent efficient and effective health care. Rather, they could reflect over-servicing or historical legacies unrelated to the need for health services.

Table 4 Comparison of the national and NT health workforce by population and burden of disease, 2006

Workforce	Professionals per 1000 population	Professionals per 100 DALYs[1]
Medical practitioners		
NT	2.65	1.34
Australia	2.75	2.08
Registered nurses		
NT	8.96	4.51
Australia	9.79	7.40
Enrolled nurses		
NT	0.75	0.38
Australia	0.94	0.71
Aboriginal health workers		
NT	1.07	0.54
Australia	0.05	0.04
Total		
NT	13.44	6.77
Australia	13.54	10.22

[1] Disability Adjusted Life Years

Sources:

ABS. Australian demographic statistics, June 2008. Cat. no. 3101.0, Table 4. Canberra: ABS, 2008.

AIHW. Health and community services labour force 2006, Table A4.6. Cat. no. HWL 43. Canberra: AIHW, 2009.

Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez A. The burden of disease and injury in Australia 2003, Table 5.5. Cat. no. PHE 82. Canberra: AIHW, 2007

Discussion

The baseline projections from the NT workforce models indicated that over the period 2006 to 2022, the supply of medical practitioners should exceed the growth in requirements for their services from a growing and ageing population and this gap widened over time. For nurses, the projection initially showed the requirement for nursing services exceeding supply, but after 2015 this reversed and the excess supply of nurses increased over the remainder of the projection period. These results depend, however, on the NT's ability to continue to attract and retain health professionals at past levels and to accommodate an increasing number of nursing graduates.

Mobility in the health workforce is an important issue for the NT[4] and the modelling further emphasised the NT's vulnerability to changes in migration patterns. If inflows of health professionals were to reduce or outflows increase relative to past patterns, the NT's ability to grow its workforce could be substantially impaired. The NT's requirement for health professionals is, however, relatively small compared with the large pool of interstate (and international) medical practitioners and nurses upon which it could draw so maintaining flows may be more dependent on the cost of recruitment (budget implications) and the attractiveness of the NT as a location rather than the number of potential candidates. Recent expansions in university placements also present an opportunity to secure more graduates and provide a steady, reliable source of growth for the workforce. The NT appears to be an attractive location for young health professionals so they may be readily enticed to come. The challenge, however, will be to retain them as younger health professionals appear equally prepared to leave if employment and training opportunities are perceived to be better elsewhere.[4,42]

Reducing outflows would be particularly beneficial to the NT. It could enhance expansion of the workforce, reduce recruitment costs and improve productivity.[4] DHF has reduced turnover in the nursing workforce over recent years, but about 40% of the workforce still leaves each year.[4] These departures mean that a large number of nurses need to be recruited to replace those departing as well as extra nurses to expand the workforce. If turnover is not reduced, the number of nurses that need to be recruited each year will increase in line with the size of the workforce. In addition to the recruitment burden, turnover also reduces productivity as newly hired staff are likely to be less effective than those they replace and remaining staff may become less efficient as they train new employees, take on extra tasks or responsibilities and increase the time spent on recruitment.[4] No allowance was made for this reduction in productivity in the modelling, but if stability improves, less of these efficiency losses may mean that more services can be provided without additional staff.

Mobility also influences the age structure of the workforce. For medical practitioners, net migration was positive in older age groups leading to an increase in the proportion of practitioners aged 50 years and over and a reduction in middle aged practitioners. These patterns had implications for the amount of working hours (older practitioners tend to work fewer hours) and retirement exits. For nurses, net migration was negative in older age groups and combined with a large intake of graduates who were expected to be mostly in younger age groups, resulted in a reduction in the proportion of older nurses. Although this meant that the NT's vulnerability to the retirement decisions of nurses diminished, turnover may increase and the depth of experience reduce.

Local graduates present an opportunity to secure health professionals at the beginning of their career and they are more likely to remain in the NT than interstate graduates. Accordingly, increasing their number could reduce mobility. They will also have a

greater knowledge of the unique aspects of work in the NT. The establishment of an NT medical school in the near future should increase the number of local medical graduates.[31] There are already local nursing graduates, but their number is presently less than the number of places available on the DHF graduate nursing program. This circumstance is, however, likely to change and it could be that local graduates exceed the number of places available on the program. The risk for the NT of this situation is that should these graduates be unable to find alternative pathways into the nursing workforce, they may choose other careers or move interstate to find positions.

Although positive, the projections from the models would still mean that Territorians are likely to be disadvantaged relative to Australians as a whole in their access to health professionals. There are far less medical practitioners and nurses available to meet the NT population's health needs than there are at a national level. This deficit is likely to mean that NT health professionals face a more pressured work environment than their interstate counterparts and Territorians find it more difficult to access their services.

The growth projected by the models may narrow the gap, but it would be unlikely to eliminate it. For example, given its burden of disease and injury, the NT would have needed to have a workforce of 3095 nurses (63.9% larger) in 2006 to be comparable to the national average. A level similar to this was projected to be achieved in 2022. Without a change in the burden of disease and injury, 3919 nurses would be required in 2022 to be comparable to the national average. With the majority of nurses in the NT being employed by DHF, such an increase would have implications for recurrent funding with sizeable increases or redistributions required. Capital funding would also need to increase in order to expand hospitals and other health service infrastructure.

In addition to the overall size of the health workforce, it is important to ensure that health professionals are located where they are most needed and have expertise in areas of high demand. The regional analysis showed that the greatest increase in the requirement for nurses would be in the Darwin region and it may be relatively easy to attract nurses to work there, but the next area of greatest need, East Arnhem, may be more problematic as it would require recruiting nurses with an aptitude for work in remote areas and typically, new recruits tend to require substantial training and support.[4] Retention can also be a challenge.[4] Meeting the needs of the elderly Territorians will be a challenge for both professions with demand from people aged over 65 expected to double over the projection period. This group may have multiple conditions complicated by their age that make care more complex and resource intensive. From a disease perspective, key specialty areas where more expertise will be needed are cardiology, oncology and neurology.

The results of the NT modelling differ from previous work by the NHWT and Preston.[16,19] These models indicated that the NT needed additional graduates for supply to meet demand. The disparity arises for several reasons: first, NHWT and Preston allowed for a shortage of health professionals at the start of the modelling period and this enhanced the gap throughout the projection period. Second, the NHWT model estimated demand using a constant annual increase of 3.8% based on population growth with weightings for Indigenous status and the elderly. Preston applied a population age profile factor of between 2.2% and 3.7%.[16] The factor was based on age related usage of nursing services in hospitals, aged care homes and other health and non-health setting that require registered nurses.[16] The needs approach of the NT models produced lower annual growth rates: 3.2% at the beginning of the projection period, which then declined to 2.4% by the final year. As noted previously, this growth only accounted for the effects of population growth and ageing; levels of ill-health remained unchanged. Third, the national model set inward and outward migration at the same rate so there was no growth from this source. It also

allowed for retirements and exits for other factors. Attrition in Preston's model was based on net separations, which were determined from the change in the proportion of people with a nursing qualification that were still in the workforce between different ages. Migration was allowed for with a fixed intake of overseas nurses. The NT models are likely to better account for the impact of mobility; however, they may understate exits and re-entries due to study, ill-health, career change and other reasons. Preston indicated that these exits may be quite substantial for nurses, particularly in the early years as graduates decide they do not like the nature of the work.[16] Data on these exits in the NT was limited. Furthermore, it may be that losses are only temporary if exiting health professionals are replaced through immigration. Further research is recommended to clarify the extent and nature of these movements and whether they are offset by immigration.

More generally, better data on the existing NT health workforce (including graduates) – their number, age and working hours – would enhance the quality of the supply projections. Although census data was used as the most reliable estimate of the NT health workforce (public and private sector), it only provides a snapshot of health professionals resident in the NT at a specific point in time every five years. Occupation was also based on a classification of people's responses rather than registration with a professional body. The implementation of national registration scheme in 2010 may better identify health professionals working full-time in the NT and improve response rates to the AIHW labour force surveys. At present, the low NT response rate combined with a high number of registrants, few of whom may be working full-time or residing long-term in the NT, means that this source of data is unreliable for the purpose of modelling and was only used when other sources were no better or at odds with anecdotal evidence. With improvement, these surveys could provide more detailed and regular information on the NT health workforce than the census.

Other limitations of the NT medical and nursing models included:

- use of hospital data to determine workforce requirements – activity in this sector may not be representative of the workforce requirements for other sectors.

- the DALY does not allow assessment of the workforce requirements associated with preventing illness.

- no allowance was made for the impact of fiscal, policy, infrastructure and other factors. These factors may constrain growth in the health workforce, for example, for DHF to employ the additional nurses projected to be available in 2022, it would require additional annual funding of more than $90 million in 2006-07 prices.[43]

Despite these limitations, it is hoped that by highlighting the above issues, the projections will facilitate a more sophisticated discussion in the NT about the demand and supply of health professionals. The benchmark analysis demonstrated that the NT is an area of low supply where increasing the health workforce could generate greater benefits than might be achieved from the placement of health professionals elsewhere in Australia. In particular, it would benefit Indigenous people as they bear the greatest burden of ill-health in the NT. It also suggests that the needs-based projections should be considered a minimum growth requirement. To improve the health of Territorians, greater expansion would be required. Facilitating the entry of graduates, particularly local students, and initiatives to improve retention in the health workforce will also be important for ensuring that health services continue to remain accessible to all Territorians.

Appendix 1 Methods for estimating the future health workforce

Introduction

The Health Workforce Modelling Project was established by the Strategic Workforce Committee of the Department of Health and Families (DHF) to develop a model to project the future demand for and supply of NT health professionals. The model was to take into account key issues of relevance to the NT, in particular, high turnover in the workforce and the high level of ill health in the NT Indigenous population. This report appraised the approaches and techniques for modelling the future health workforce that have been used in Australia and internationally in order to determine the method most suited for use in the NT's model. It aimed to identify the different approaches and techniques for projecting the future workforce and to evaluate their strengths and weaknesses in light of the NT's circumstances.

This review of the prior modelling is structured as follows: first, the approaches to modelling the supply of health professionals and key issues with each approach are outlined. A similar format is then followed for assessing the approaches to modelling the demand for health professionals. Third, recommendations are made on an approach for use in the NT's workforce model. Fourth, the statistical techniques for generating the projections are evaluated and recommendations made for the model. Fifth, the data requirements of the recommended approach are outlined, and finally, consideration is given to other issues relevant to modelling the NT's health workforce.

Approaches to modelling the health workforce

Estimating workforce supply

The primary approaches to modelling supply are time series analysis and the "stock and flow" approach. In Australia, both approaches have been used by the Department of Human Services (DHS) in Victoria.[13] The NHWT model used the stock and flow approach.[19]

Stock and flow approach

A stock and flow approach involves identifying the size and activity of the current workforce (stock), sources of inflows and outflows from the stock and important trends or influences on the stock and flows. To project future supply, the initial stock is moved forward based on expected inflows and outflows and allowing for the impact of important trends and influences in the stock. Key variables included in this approach are listed in Table A5.

The starting point of this approach is the stock of health professionals. A key issue in determining the stock of individuals is to identify the population of interest, for example, whether to model enrolled nurses separately to registered nurses or to include individuals in non-clinical roles (research, administration, etc) if clinical services are the workforce's output of interest. Once determined, studies usually segment the stock into age and sex cohorts (commonly five year groups in Australian studies) and convert headcount numbers to full-time equivalents (FTE) to adjust for differences in participation. Additional segmentation may occur based on professional and

geographic characteristics. The adequacy of the stock is also usually assessed and any deficits or surpluses carried forward into subsequent years of the projection period.

Table A5 Key variables in stock and flow models of health workforce supply

Stocks	Flows
Number of individuals	*In*
Demographic characteristics, particularly	Graduates
• age	Immigration
• sex	• international
Professional characteristics e.g.,	• interstate
• specialisation	Re-entry after temporary exit
• employment setting (public/private, acute/aged/community care, etc)	
Geographic characteristics e.g.,	*Out*
• metropolitan/non-metropolitan	Retirements
Participation	Maternity
• clinically active	Mortality
• working hours	Morbidity
Adequacy – current deficit/surplus of workers	Emigration
	• international
	• interstate
	Other departures due to career change, economic, environmental factors, etc
Other	
Productivity	
Policy	

The key source of inflows to the health workforce will be people who are undertaking the necessary educational and/or training requirements. Although only those that complete the required course add to the stock, it may be necessary to consider the entire educational pathway to account for availability of places (whether all are filled), the lead-time between commencement of study and graduation and attrition from courses (not all people commencing a course will complete it). Other major sources of inflows are migrants and people re-entering the workforce after a temporary absence such as women returning after childbirth. The key outflow included in stock and flow models is retirements and this tends to be done by moving the age cohorts of workers through the years of the projection period and exiting part of the group each year once they have entered the relevant period until all are retired. The inclusion of other outflows tends to be dependent on data availability or the application of estimates.

Key trends and influences incorporated in stock and flow models are age and sex differences in participation; policy (e.g., expansion of educational places); and productivity improvements. It has been suggested that technology changes should also be considered as these can affect productivity, for example, information technology may reduce time spent on administration thereby increasing clinical output, or distance education may increase the number of people able to take up educational places.[44]

Time series analysis

Time series analysis applies statistical techniques to historical data to derive trends, which are then projected into the future as an estimate of workforce supply. For example, DHS used survey data on total hours worked by nurses to calculate FTEs in eight consecutive years.[13] Two methods were used to calculate FTEs – the resources method, which caps the hours of nurses working more than 38 hours per week at one FTE; and the supply method, which counts the total hours worked and divides by 38. Dividing FTE supply by FTE resources indicates the extra supply (through additional hours of work) that could be gained from members of the workforce.[13] Trend lines in these data series were then determined using linear regression and Holt-Winters time series analysis and the model of best fit used to project supply into the future.[13] The time series analysis generated more conservative estimates of growth in the workforce than did the stock and flow approach. DHS chose, however, to use the stock and flow approach for its primary estimate of supply as it can better reflect policy impacts.

Strengths and weaknesses

The data requirement of the stock and flow approach would be much greater than the time series approach due to the number of variables and the need for time series data to determine trends in demographics, participation and flow variables. This requirement will increase the resources needed for collection, storage and analysis of data. The viability of the model will also be dependent on the availability and quality of data.

The stock and flow approach allows more dynamic modelling of supply than the time series approach. The time series approach can only reflect past policy choices, which may be different from present or future policy. Furthermore, it may not capture the effect of recent changes if there is a lag between policy changes and its effect on the workforce. For example, recent increases in educational places will not affect the workforce until the new commencements complete their course some years in the future.[13] Even where such changes are reflected in the data, its effect on a trend line would be muted by data from earlier years.

Another issue with time series analysis is that it may not suit small workforces where entries and exits could have substantial impact on the trend lines. For example, the impact on growth of one person joining in a workforce of 10 is much greater than in a workforce of 1000 people. The stock and flow approach may be better at showing change in small workforces especially if increases in past staff have been opportunistic appointments rather than real growth in supply or that growth is lumpy in nature, that is, unmet demand has to reach a critical point before it is economic to employ an additional health professional.

Strict management of a stock and flow model may be needed. It may be tempting to add more variables or further segment the stock to 'improve' estimates; however, such refinements also increase the level of uncertainty in the results and the complexity of the modelling. Accordingly, to be worthwhile they need to have a sound theoretic basis, clear definitions, be measurable (or have reliable proxies) and to appreciably increase the usefulness or reasonableness of results.[45]

Estimating workforce demand

Seven approaches to modelling workforce demand were identified in the literature: needs-based, utilisation-based, effective demand, effective infrastructure, models of care, macro-economic and benchmarking models.[20,45] The following sections explain each model and outline key issues with their use. In the final section, a comparative assessment is made of the approaches.

Needs-based models

Needs-based models use measures of the health of the population as the basis for determining workforce requirements.[20] They require information on the level and distribution of the need for health services across the population, the necessary treatments to address that need and the workforce required to provide those treatments.[45] Growth in population and changes in the health of the population are used to project the future need for treatments and thus, the required workforce to meet that need.

Defining 'need' may be difficult as perceptions and the meaning of need may differ between individuals, professional groups and communities.[20] Some indicators that have been used or suggested in the literature are age and sex-specific prevalence rates,[46] self-assessed health status, health risks, disease incidence and mortality.[9]

Once an indicator has been selected, it must be linked with medical treatments. Failing to identify the appropriate treatment(s) could mean that the analysis uses inefficient and ineffective treatments that overstate the workforce requirements.[45] Once identified, further work is required to determine the amount of workforce resources used in the treatment (relative to other resources). These activities are likely to be time consuming and difficult, but decisions and assumptions made on these components will be critical to the output from the model.

This model assumes that demand would be less in populations with fewer needs.[45] It has been suggested, however, that populations in better health may continue to demand more health services as they seek to maintain their stock of health (rather than restore it) or to achieve even greater levels of 'healthiness'.[45] Moreover, an improvement in the health of the population does not necessarily imply a reduction in the need for health professionals especially if that improvement depends on the continued delivery of prevention services. A final issue with this approach it that it does not consider economic, funding, infrastructure or other constraints to meeting needs.[20]

Utilisation-based models

Utilisation-based models use data on health service usage as a proxy for need.[20] The future workforce requirement is estimated by applying usage rates (based on past trends) to the demographic profile of the population in future periods.[20] DHS in Victoria and the national models by NHWT use this approach.

A key advantage of this approach is that usage data is often readily available. The approach does, however, assume that current service use is rational and adequate and that services are located where needs are greater.[45] It also assumes each cohort will have the same requirements in each age category as past cohorts.[47] If, however, the population is getting healthier as life expectancy increases then usage patterns may change with each cohort.[9]

Another issue will be whether constraints in providing an adequate supply have affected utilisation rates.[20] Where constraints mean that societal wishes or values have not been met, utilisation-based models will understate demand; however, there may be some constraints that should reasonably and appropriately be reflected in utilisation. For example, it is not always feasible to match growth in needs with the construction of new infrastructure or the availability of funding.

Effective demand models

This approach allows assessed needs or usage to be constrained by the financial ability of the economy or health system to meet those requirements.[20] It requires

information on the size of the economy, health care expenditure and the proportion of health care expenditure that is allocated to the workforce of interest.[13,20] In each period of the model, the number of workers that could be employed is limited by the available economic resources.[20]

This approach acknowledges that the decision on the amount of money that will be put toward health by individuals and governments may not necessarily be based on need or allow for all need to be met. It may be useful when there are distinct changes to taxation or government spending priorities that may mean that additional or less funding will be available for health services (utilisation models) or to temper needs-based models with fiscal reality. The data and analytic requirements of these models are likely to be substantive.

Effective infrastructure models

Effective infrastructure models are used when the physical capacity of the non-labour components of health services limit the employment of additional workers.[20] For example, if additional intensive care equipment cannot be purchased, there is little point in employing extra staff for these services even if need increases. Similarly, the employment of additional staff may be constrained by the construction program for new facilities. This approach requires information on expected changes to relevant equipment, buildings and other capital, how it will impact on staffing in the period before it comes in to operation and after start-up (e.g., a 200 bed facility may be built to accommodate future increases in demand, but only 100 beds put into operation at the start with the opening of further beds staged over subsequent years).

Models of care

This approach considers all workforce functions required to efficiently provide a set of services that give the best outcomes to patients.[20] It is best suited to modelling workforce requirements for particular streams of care, for example, emergency care and perioperative care.[48] In addition to requiring a forecast of growth in demand, this approach requires a definition of the best model of care, which in turn, defines the necessary quantum and mix of skills required to deliver that care.

The advantages of this model are that it considers workforce supply in a more integrated manner, it is outcome focussed and aligns with service delivery plans.[49] It recognises that care is often multidisciplinary and substitution can occur between occupational groups.

The disadvantages of this model are that it limits projections to activities where there is a definable model of care, but where there are several viable options, it is not clear how to choose between them.[49] The models of care approach is likely to be complex and require a substantial volume of information, which will have implications for the resources required to implement and maintain the model. It would also be difficult to use for an entire professional group due to the numerous models of care that would have to be considered.[49]

Macro-economic models

Macro-economic models link growth in the health workforce with growth in the economy using indicators such as gross domestic product (GDP).[50] The rationale behind these models is that increases in GDP permit, after a lag of several years, additional expenditure on health services for previously unmet need and to enable access to new services.[50] As labour is the primary component in the provision of health services, the increase in expenditure means an increase in the health workforce.[50] The

strength of the relationship between growth in the economy and the health workforce is determined by correlating workforce supply with GDP.[50]

A key problem with this approach is that the number of physicians has increased over time so it will correlate with any other upward trend regardless of whether there is a causal link between the two.[45] Accordingly, economic growth may be an unduly simplistic or inaccurate estimator of workforce requirements. Furthermore, it is not clear that the relationship between GDP and the workforce truly represents society's wants and is assured of happening.[45] It is also not clear how this approach accommodates future advances in technology, for example, those that would improve productivity or change the services demanded. The key advantage, however, of this approach is the simple data and modelling requirements.

Benchmarking models

Benchmarking models compare workforce-to-population ratios in particular regions or health care systems (benchmarks) with the ratios in the locality of interest.[45] This approach assumes that the benchmarks are desirable and attainable and thus, what should be available to the population in the locality of interest.

A difficulty with this approach is what the benchmarks actually represent. Although the model assumes that they embody efficient and effective health care, they could represent over-servicing, historical legacies or other idiosyncratic location of health services.[45] This approach will, however, be useful for avoiding further investment in areas with high per capita numbers of health professionals and for pointing to areas of low supply where additional resources may give greater benefits.[45]

Comparative analysis of demand approaches

The models of care approach would provide the most detailed projection of workforce requirements, but could be difficult to apply to a whole profession. The approach highlights, however, the issue of substitution between practitioners, for example, the role of the nurse practitioner has implications for the demand for both nurses and doctors. The models of care approach might be best applied at a speciality or locality level (e.g., renal, oncology, remote health services) where service delivery is well defined (ideally evidence-based) and multidisciplinary.

From a resources perspective, the models of care approach would have the most data and analytical requirements and a macro-economic approach the least. The macro-economic approach may, however, give the least robust projection. The existence of universal, subsidised cover through Medicare means that access to health services is not directly linked to ability to pay and increases in wealth may make little difference to demand. Accordingly, it is not clear that economic activity (as a proxy for wealth), particularly at a state level, will be strongly related to the demand for health services and thus, health workforce requirements.

Like the macro-economic model, the benchmark approach also has fewer data and analytical requirements. Unless, however, the efficiency and effectiveness of the benchmark can be established, this approach might be better used as an indicator of where to distribute workers rather than the basis for workforce requirements.

Utilisation-based approaches are common in the literature probably due to data availability and their moderate data and analytical requirements. Utilisation can also be measured for many combinations of population characteristics such as age, gender, ethnicity and service setting, which is likely to improve the quality of projections. This approach will be most suitable when it is reasonable to assume that utilisation rates in the future would be similar to those today.[45] If utilisation changes with new cohorts or

present levels of utilisation understate or misrepresent the demand for health services, this approach would poorly predict workforce requirements.

The needs-based approach is advocated in the literature as being a better indicator of the demand for health services than utilisation of services. It will be particularly useful when there are marked inequities in health status and health service utilisation within the population. Fewer needs may not, however, mean less demand for services and not all needs may be satisfied. The latter is evident in the prioritising of emergency patients, waiting lists for elective surgery, co-payments for primary and other care and exclusion of services from universal cover under Medicare (e.g., dental, optical).

The effective demand and infrastructure approaches refine needs and utilisation models to allow for policy and funding constraints. They may add a further layer of uncertainty to the results and have to be applied carefully to utilisation models, which could already reflect these influences. Effective demand and infrastructure models might be most appropriate for specialty workforce analyses where these constraints may be more evident, measurable and amenable to making projections.

Recommendations for the NT

Initially, projection models are to be developed for the medical and nursing workforces. Information on specialties is also desired. It is recommended that a stock and flow approach be used to model workforce supply as this approach will be best able to reflect future changes.

A needs-based approach is considered to be the best approach for projecting workforce requirements. Indigenous Territorians are using health services at levels that are less than might be expected given their health status and society's expectations and values as shown by the Commonwealth Government's intervention in Indigenous communities. Under-use of services would mean that an utilisation model would be likely to understate requirements and perpetuate current inequities. Possible impediments to the application of this approach will be the availability of a suitable measure of needs and the ability to translate it into demand for services.

Despite the issue of Indigenous utilisation, it might be useful to make projections using the utilisation approach. It would give a lower bound estimate of requirements and has the following advantages:

- it would be less complex and have less data requirements;
- usage data is available and can be updated annually;
- it would reflect present funding and policy positions; and
- it would be consistent with the approach taken interstate and nationally.

A models of care approach would be recommended for projecting the requirements for service locations, but as the resource requirements (data and analytical) for generating these projections are likely to be considerable, it might be best used selectively for specialty services. A needs or utilisation model would generate a higher bound estimate of specialty requirements, but it will not allow for substitution from generalists with relevant training or between occupational groups if care is generally provided by a multidisciplinary team.

It is not necessary for the NT to adhere to only one approach to modelling. A combination of approaches including effective demand and infrastructure should be used where data can be reliably applied to refine the projection. A projection period of at least 10 years is suggested. Ten years allows time for workforce, policy or funding

adjustments to be made.[20] Projections could be made for lengthier periods, but projections will become more doubtful as errors and uncertainty in the data compound with each additional year.

Techniques used in projecting the future health workforce

The modelling approach guides the type of data used in the workforce analysis. The projection technique determines how dynamically the data is used. There are two main techniques used in workforce modelling: deterministic and stochastic methods. This section describes these techniques and issues with their use in the NT.

Deterministic methods produce single point estimates and their use has been common in Australia (e.g., DHS).[13,51] In a stock and flow model of supply, this technique would take the workforce at the start of the projection period, add entries to the workforce and deduct exits to derive the size of the workforce in the second year. In the next year, the second year workforce is the starting point and the same procedure is followed to derive the third year workforce and so forth until the end of the projection period. This technique makes no allowance for uncertainty in the variables in the model.[51] This issue can be partially addressed by including sensitivity analyses to show the impact of variation in key variables. A key advantage of deterministic models is that they only require spreadsheet programs such as Excel to be run and updated.

Stochastic techniques reflect uncertainty by using random numbers and probability distributions to generate a range of potential outcomes.[51] Examples of these techniques include Markov chain analysis, which produces transition matrices based on important characteristics to calculate the change from period to period (this approach is used in NHWT models);[20] and Monte Carlo simulation where a range of values is specified for key inputs and these are randomly drawn upon to generate deterministic results, which are aggregated into a final result (an output with a value range).[51] Although stochastic techniques better incorporate uncertainty, they require knowledge of the techniques and sophisticated software, which may not be readily available in the NT. Moreover, even if available these skills may be difficult to retain or reacquire with the movement of people in the high turnover environment of the NT.

It is recommended that deterministic techniques be used in the NT's workforce models. An Excel-based model would facilitate the establishment and continued operation of the model as personnel with skills in spreadsheet programs should be readily available and Excel is available on all Departmental computers. Uncertainty can be addressed by sensitivity analyses on key variables such as the volume and characteristics of new entrants and migration rates.

Data requirements of models

A constraining factor for the NT model is likely to be the availability and quality of data. This section lists the data required and potential sources for that data for a stock and flow model of workforce supply and a needs-based model of workforce requirements. Issues associated with the data are also discussed.

Table A6 shows the key data required for a stock and flow model of workforce supply. A "baseline" workforce needs to be established and at a minimum, the workforce needs to be segmented by age and sex.[20] Further characteristics such as qualifications and geographical location (see Table A8) could also be included if appropriate. Trends in participation by age and sex are needed for future years. The age and sex distribution

of entrants and exits is also needed and a participation rate if this differs from that of their age/sex cohort. The inclusion of inward and outward migration will be important due to staff high turnover in the NT and again this information will be needed by age and sex.[4] Factors affecting entries and exits should be considered and relevant data included, for example, the graduate pipeline.[20]

Table A6 Key data items and potential sources for a stock and flow model of workforce supply

Data items	Potential data source
Number (headcount)	AIHW labour force surveys (AIHW LFS); Registration boards; DHF personnel information and payroll system (PIPS); Australian Bureau of Statistics (ABS); Medicare
Age and sex mix of workforce	AIHW LFS; Registration boards; PIPS; ABS
Working hours	AIHW LFS; PIPS; ABS
FTE hours	NT legislation
Graduates or graduate pipeline (course commencements and attrition)	Surveys of university and vocational education facilities, hospitals and other health providers; Registration boards
Migration (in/out) • interstate • international	PIPS; ABS; CDU mobility studies
Re-entrants	PIPS; Registration boards
Exits (retirements, career change, etc)	PIPS; DHF exit interview data
Age and sex mix of entries/exits	AIHW LFS; Registration boards; PIPS; ABS
Productivity	AIHW LFS; PIPS; surveys; Industrial agreements

Key data sources are the AIHW labour force surveys, registration boards, the department's payroll system (PIPS) and Australian Bureau of Statistics (ABS) data. In the NT, the response rate to the labour force surveys in recent years has been low so the reliability of the data is likely to be poor. Registration boards hold information that could be useful, however, it is not necessarily available in electronic form and protocols and approvals may need to be established before access can be obtained. PIPS data is more readily available; however, it may limit the ability to make projections beyond the department's workforce. Data from the ABS census may be a good source for the model, but a special request may be required to obtain timely data at a level suitable for the model.

Table A7 shows the key data required for a needs-based model of workforce requirements. The order of the data in the table reflects the cascading nature of the needs approach with data on the health of the population needing to be mapped to population forecasts to determine the type and level of health needs by year. Health needs then require mapping to health service requirements, which in turn determine the workforce requirement. The key area of difficulty is likely to be the mapping of health needs to health service requirements. The data used here will directly impact on workforce requirements, for example, there are different workforce implications if the health need is met by treatment at a hospital or managed by a general practitioner.

Table A7 Key data items and potential sources for a needs-based model of workforce requirements

Data items	Potential data source
Population by age and gender for each year of the projection period	ABS
Disease incidence and prevalence or other measures of the health of the population	NT burden of disease and injury study, mortality and morbidity data from DHF and ABS
Health service requirements	Consultation with experts, surveys, DHF data, Medicare data
Workforce requirements	Consultation with experts, surveys, DHF cost or payroll data, Medicare data

Table A8 shows other data that may be used in estimating future workforce requirements. Specialty areas and geographic location would allow further segmentation of the workforce projections. Usage data could be used to generate an utilisation-based projection as an alternative to the needs-based model if data or mapping problems make the results of that model unreliable. Health care financing, economic information and capital works programs could be used to apply fiscal reality and infrastructure limitations to the needs-based model. Service standards can act as benchmarks or be used to calculate necessary workforce for treatments. Technological developments and consumer expectations may change the type and level of services required.

Table A8 Other data items and potential sources for determining workforce requirements

Data items	Potential data source
Specialty areas/skills/qualifications	AIHW LFS; PIPS; Registration boards
Geographic location	ABS; PIPS
Workforce shortage/surplus	PIPS (overtime); DHF use of agency/casual staff; vacancies; worker/patient ratios
Health service utilisation	AIHW; DHF databases (Caresys, CCIS, PCIS, etc); Medicare
Health expenditure	AIHW
Economic activity	ABS; NT Treasury; Access Economics
Capital works program	NT Treasury
Service standards (ratios of workers to patients)	DHF databases; health services; professional organisations
Technological change	DHF expenditure data; expert advice; DHF or Medicare policy
Consumer expectations	Surveys; Consumers Health Forum of Australia

Other issues

Estimating future workforce requirements and the capacity to meet those needs will highlight the extent of the gap between supply and demand and when action is required to address the imbalance. It will be important that users of this information are assured of the robustness of the results and understand how they have been derived. A conservative approach should also be taken where data is missing or of poor quality and estimates are needed.[45]

The generation of single point estimates of supply and requirements using a deterministic model will disguise the level of uncertainty in the model. Sensitivity analyses that show the implications of using higher or lower values for key variables could partially address this issue. The assumptions made in the model should also be clearly indicated to users and sensitivity analyses conducted on these as might be relevant. The reasonableness of the model's results could be tested by comparing projected trends with historical increases in workforce, health expenditure and DHF budget funding (DHF being the primary employer of health professionals in the NT).

A further use of the model could be to show the outcome of policy solutions such as increasing graduates and decreasing attrition. In addition to these supply-side responses, demand-side initiatives could be considered. For example, demand management or service delivery redesign including changes in work practices and scopes of practice are possible options for constraining demand.

Conclusion

The most common approach to modelling the supply of health professionals has been to use a stock and flow approach. This approach takes the current workforce (stock) and moves it forward in time based on expected entries and exits of workers and important trends or influences on the workforce and these inward and outward flows. This approach is recommended for the NT model as it can include key factors impacting on the NT health workforce including graduates, retirements and interstate and international migration. It can also show the impact of changes in these flows. The data requirements of this approach are, however, quite high and the credibility of the projections will depend on the availability and reliability of the data inputs to the model.

A needs-based approach is recommended for projecting workforce requirements to capture the unmet need in the Indigenous population. This approach uses population growth and the level and distribution of health need across the population to project the future need for treatments and thus, the required workforce to meet that need. Key issues with approach will be the availability of a suitable measure of health need and the ability to translate it into demand for the services of health professionals.

It is not, however, necessary for the NT to only use these approaches in its workforce modelling. For example, a models of care approach may be more appropriate for examining specialty areas or where care is delivered by a multidisciplinary team. An utilisation-based approach could be useful to give an estimate of requirements given current access, funding and policy positions. Financial and infrastructure constraints could also be incorporated in needs-based models where data can be reliably applied to refine the projection.

The use of deterministic methods, which produce single point estimates of the workforce in each period of the projection, is recommended so that use of the model is not dependent on knowledge of sophisticated statistical concepts and techniques. This method is, however, less able to address uncertainty in the data. This issue can be addressed by conducting sensitivity analyses that show the impact of change in key variables and assumptions. The projections should be made over a period of at least 10 years to allow time for lagged effects of workforce, policy or funding changes. The period should not, however, be extended too far as means that the projections become more doubtful as errors and uncertainty in the data compound with each additional year.

Appendix 2 NT Government statistical regions

Figure A11 NT Government statistical regions
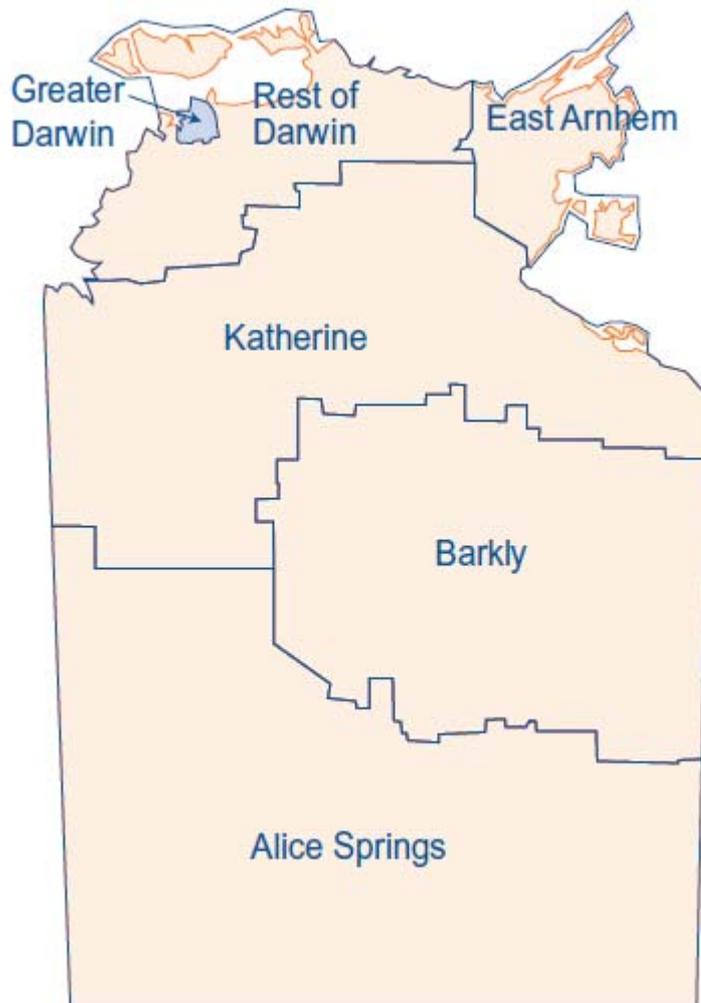
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