NationalHealthWorkforce
Planning and Research Collaboration

Refining the National Workforce Planning Model

NHWPRC

Final Report

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Prof. Anthony Scott, Dr. Peter Sivey

Melbourne Institute of Applied Economic and Social Research
& Australian Health Workforce Institute,
The University of Melbourne

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Enquiries concerning this report and its reproduction should be directed to:
Health Workforce Australia
Information, Analysis and Planning
GPO Box 2098
Adelaide SA 5001

Telephone: 1800 707 351
Email: iap@hwa.gov.au
Internet: www.hwa.gov.au

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Preface

In 2006 the Council of Australian Governments (COAG) agreed to a significant national health workforce reform package to enable the health workforce to better respond to the evolving care needs of the Australian community, while maintaining the quality and safety of health services. The COAG package included the establishment of the National Health Workforce Taskforce (NHWT) to undertake project-based work and advise on and develop workable solutions for workforce innovation and reform. The NHWT ceased operation with the establishment of Health Workforce Australia, which assumed responsibility for the ongoing commitments and work program of the Taskforce in 2010. HWA was established by COAG through its 2008 National Partnership Agreement on Hospital and Health Workforce Reform and tasked with facilitating more effective and integrated clinical training for health professionals, provide effective and accurate information and advice to guide health workforce policy and planning, and promote, support and evaluate health workforce reform.

The National Health Workforce Planning and Research Collaboration (‘the Collaboration’) was established by the former Taskforce. The Collaboration is a tri-partite partnership between the Australian Health Workforce Institute, PricewaterhouseCoopers (PwC) and the NHWT (now HWA), and was created to undertake a significant body of national health workforce research over a three-year period, including advice and development on future supply and demand models for the health workforce.

The ‘Refining the National Workforce Planning Model’ project was undertaken by the Collaboration to explore the potential for improvement to National Health Workforce Planning Tool; the principal statistical model developed by NHWT to generate health workforce projection and is currently being deployed by HWA as the basis for ongoing supply and demand modelling.

All recommendations in this report are planned to be either incorporated in the updated National Health Workforce Planning Tool that is being built as a component of the National Training Plan in 2011 or, in relation to the recommendations for further research, taken to the HWA Planning and Research Advisory Committee for further consideration. The views in this report are those of the authors and do not necessarily represent those of NHWT or HWA.

Acknowledgements

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Executive summary

Introduction

1) This project examines the impact of changing the assumptions of the Health Workforce Planning Tool (HWPT) on the robustness of projected workforce requirements. One-way sensitivity analysis is conducted for two different workforces: radiographers and medical practitioners.

2) The recommendations of these models have substantial cost implications and it is important that uncertainty around workforce projections is quantified and explicit. Even a difference of say, 10 health professionals, which may seem small in number, can have large cost implications of hundreds of thousands of dollars in training costs and eventual costs to Medicare and the health system.

Key recommendations

Changes to the way the model is used and results presented

3) The models' results are sensitive to changes in a number of assumptions. Some assumptions, such as exit rates, have a large impact on projected requirements, whilst others, such as retirement rates, do not. *A section on sensitivity analysis should be included in the HWPT user manual.*

4) *Future applications of HWPT should, as a matter of routine, systematically test the sensitivity of the projected requirements to changes in agreed key assumptions.* The workforce requirements from each model should not be presented as a single number, but as a range, to reflect uncertainty in workforce requirements as key assumptions change.

5) *Future applications of the model should, on the basis of sensitivity analysis, include as key recommendations the priorities for future data collection for each workforce.* These can then be systematically/regularly fed into the national minimum data set, or used to design future specific data collection exercises, surveys, or future research.

6) There are issues with forcing the model to 'balance' in a specific year. The year chosen is arbitrary and changing this can have quite an impact on the projected training requirements. *The balancing year should justified and different balancing years should be used as part of the sensitivity analysis.*

Priorities for future data collection

7) Assumptions about exit rates have a large impact on the number of training places required. The quality of the data underpinning exit rates for specific workforces needs to be carefully assessed. For many of the allied health workforces for example, comparing census data over time is currently the only option, but census data are inaccurate and changes in how individuals self-report their occupation can influence observed exit rates.

8) Registration data need to be linked at the unit record (individual) level over time, so exits and entries of different types can be directly measured and individuals tracked over time. *Questions on current working status (e.g. retired, working, maternity leave, etc) should be compulsory in the new national minimum dataset to enable longitudinal tracking.*

Changes to the HWPT model

9) The HWPT model should be altered to allow different types of exits and entry (retirement, raising a family, working overseas etc) to be included separately.

10) The demand assumptions have a large impact on the required training places. The model assumes a linear trend which needs to be investigated and justified more carefully for each workforce. This is partly data dependent, but explicitly *allowing the HWPT model to include nonlinear demand growth should be considered*.

11) The model only allows balancing to occur by a one-off increase in training places. This can lead to strange results and seems unrealistic. An alternative might be to *allow the model to balance by allowing training places to grow over time by x places per year to reach y places by the balancing year.*

12) An extension of the model would be to allow immigrant workers (workers who have joined the workforce as immigrants rather than graduates) to have different work hours and exit rates to Australian-graduate workers. There might be data available to inform this from surveys of doctors or the census. This extension could add information about the substitutability of Australian and immigrant health workers. *Further work should establish if immigrant health workers work different hours or have different patterns of exit and entry to domestically trained health workers and the model should be adjusted accordingly.*

Further research

13) Demand is assumed to be independent of supply. Insights and evidence from economics suggest that demand (utilisation) may increase in response to increases in supply, either through changes in prices or through supplier-induced demand. This is currently ignored by the HWPT. Explicit modelling of the interaction between demand, supply and prices should be considered, to inform further changes to the HWPT. *How to do this should be the subject of further research.*

14) The assumption of supply being equal to demand at the beginning of the period was made for all the allied health workforces in the May 2009 macro modelling project and is a key issue that will require further research/data on estimating current shortages for all workforces. *Establishing the extent to which demand is currently equal to supply, and how this is changing over time, is a key area of further research.*

1 Scope and Aims

The aim of this project is to further develop the Health Workforce Planning Tool (HWPT) as a useful resource for workforce planning. This will include improvements in functionality and flexibility whilst maintaining ease of use. We will recommend specific changes to the current NHWT model, as well as helping to define and scope future work. The project has the following objectives.

1. Conduct a comprehensive review of the assumptions underpinning the HWPT.

This builds upon PwC's work in 2008 to build an understanding of the assumptions used in the current HWPT. We review assumptions related to the structure of the model, as well as the data used.

2. Develop methods to conduct sensitivity analysis of the model's results with respect to assumptions and key parameters.

A key issue with the projections of current models is that little is known about how robust they are. They are presented as single numbers, when in fact there may be considerable uncertainty around the projections. This raises questions about how to quantify and present this uncertainty.

We review the different types of sensitivity analysis (often used in economic evaluation and decision analytic models of health care services) to examine how changes in the assumptions and key parameters of the model influence supply and demand projections. This can be used to prioritise future data collection by focusing on those parameters/assumptions that have the most significant impact on predicted workforce requirements.

3. Apply sensitivity analysis to existing models.

Following the review, sensitivity analysis is applied to two example workforces in the 2009 Macro Modelling Project conducted by PwC for NHWT: radiographers and doctors. This will then be used to:

- Identify those assumptions and parameters that have the largest impact on the models' results, and so prioritise what further data collection and analysis needs to be conducted, and
- recommend what enhancements can be made to the HWPT, whilst maintaining functionality.

2 Model description and critical appraisal of key assumptions

The HWPT is based on a standard ‘stock and flow’ approach to population projection. It is largely based on demographic changes, where the numbers in the workforce in a given year (by age and sex) are calculated from the number in the previous year (the stock) plus inflows minus exits. These projections of supply are then compared against projections of demand, usually proxied by the utilisation of health care services. If demand is greater than supply in a given year, then this is used as an estimate of the number of new training places required.

These type of models are relatively easy to implement and not technically sophisticated. They can provide quantitative projections and be used to construct different scenarios about future demand and supply. However, these models are not perfect and are based on a number of assumptions that can influence the projected workforce requirements.

Projected requirements are then used to recommend changes to the number of government-funded training places. The additional costs of training health professionals are large and require considerable investment of resources, which could have a larger impact on population health if used for other purposes. It is therefore of considerable importance to ensure that the methods used to generate the projections are robust.

There are a number of issues about this type of method for workforce planning which could be used as arguments for using alternative or complementary approaches to workforce planning:

- This model focuses solely on increasing training places as the only policy option to increase supply. In reality, there are many different policy responses to increasing supply and productivity from the current pool of the health workforce. These other options may be more effective and less costly than increasing training places (e.g. reducing exit rates).

- In general these models ignore the geographic distribution of health professionals and the distribution between the public and private sectors. More training places may simply re-enforce an already existing mal-distribution.

- In general these models assume demand (as measured by utilisation) and supply are independent, when in fact an increase in supply can directly influence utilisation of health care, either through changes in prices charged which can influence demand, or through over-servicing (supplier-induced demand).

- In general these models ignore interdependencies between different types of health professionals, and therefore ignore the potential for skill mix change and role substitution.

The purpose of this report is not to argue for an alternative model, but to focus specifically on the current version of the HWPT model.

2.1 Assumptions about demand

2.1.1 Description of how demand is modelled

In the HWPT, the demand for health professionals is proxied by the utilisation of health services. Note that the demand for health professionals is derived and based on the demand for health care services (i.e. treatments provided). To properly define the relationships between need, demand, and utilisation is beyond the scope of this report, but suffice to say they are not straightforward.

HWPT uses utilization patterns to define demand for health professionals. The model for demand in the HWPT can be expressed as follows:

$$D_t = \beta_{st} activitysimple_t + \beta_{ct} activitycomplex_t \qquad (1.1)$$

Utilization at time *t* is divided into two types: simple (*activitysimple*) and complex (*activitycomplex*). Each of these has a coefficient β_{st} and β_{ct} with $\beta_{st} < \beta_{ct}$ relating activity into demand for full-time-equivalent (FTE) health professional hours at time t, D_t. The model offers a simple specification of demand growth, where utilization grows linearly:

$$\begin{gathered} activity_t = activity_{t-1} + \delta_D \\ activity_t = cons + \delta_D t \end{gathered}$$

where $\delta_D = \alpha D_0$ where D_0 is demand in the base year and α is the percentage growth in demand entered in the ‘configure’ tab as ‘my_demand’. Actual labour demand will then grow according to the linear growth rates in *activitysimple* and *activitycomplex*.

Note that the model does allow the user an alternative: to input her own demand growth figures (for $activity_t$) for the projection period. However, this is not made explicit and the demand growth assumptions in the ‘my demand’ sheet only allow for linear demand growth.

2.1.2 Assumption: binary casemix approximation.

Where demand for health professionals is predicted based on utilization patterns, account must be taken of the differences in health professionals time that will be required for treating different conditions or complexities of conditions. The HWPT assumes these differences can be approximated with a binary distribution: “simple” cases (using less health professional time) and “complex cases” (using more health professional time). It is hard to know exactly how well the binary distribution will approximate the true distribution. This part of the HWPT is not often used presumably due to data limitations.

Possible bias caused by binary casemix approximation

The binary approximation may introduce bias when the true distribution in poorly approximated. An example is that the true distribution of casemix may be characterised by extreme values, a small minority of patient episodes that use a large amount of health professional time.

Possible changes to the model

This option is rarely used in the HWPT model due to data limitations, so should not be changed at the moment.

2.1.3 Assumption: Linear demand growth

The HWPT assumes demand grows linearly over time. In many cases, this may be appropriate, for example where there is evidence of a linear trend in the past and no a-priori reason to expect this will change in the future. However, this will not be the case for all types of health care (or health professional). Utilization growth may be increasing for some types of health procedure e.g. diagnostic imaging, or slowing for others. These phenomena could be represented by including nonlinear growth in the model. Examples include logarithmic, exponential and polynomial (squared, cubed etc) trends.

Possible bias caused by assuming linear demand growth

Where growth in utilisation is increasing rather than constant, the model will underestimate future demand and suggest too few graduate training places are required. Where growth in utilisation is decreasing, the model will overestimate requirements.

Possible changes to HWPT

In the ‘configure’ worksheet of the model an extra option could be added with three options: linear, logarithmic, exponential. Then the growth in demand specified in 'my_demand' could represent either of the three possible growth patterns:

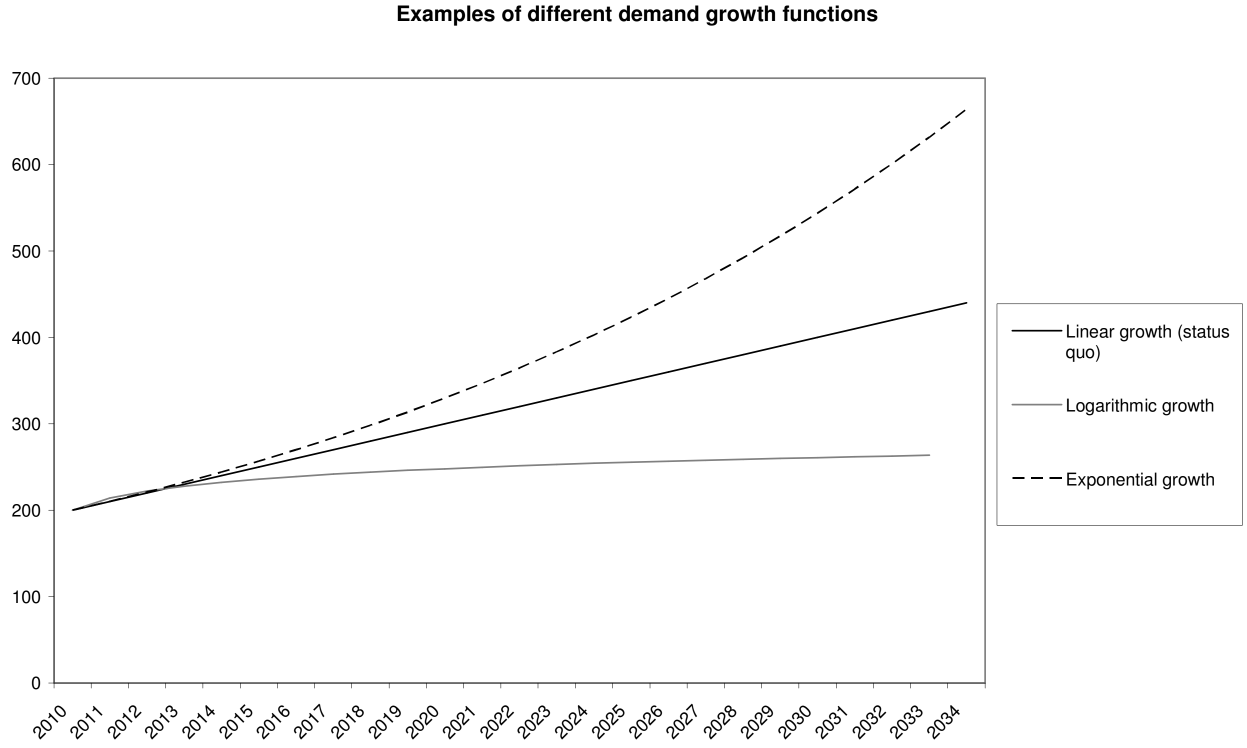
$$activity_t = cons + \delta_D t \qquad (1.2)$$

$$activity_t = cons + \delta_D \ln(t) \qquad (1.3)$$

$$activity_t = cons * \exp(\delta_D t) \qquad (1.4)$$

Figure 1 below shows examples of the three different specifications of growth rates.

Figure 1. Different rates of growth for demand



Exponential demand could be added relatively easily to the model by adding a single option (tick box or 'yes/no') which interprets the % growth (specified in the 'my demand' sheet) as exponential rather than linear, as in equation (1.4) rather than (1.2). Logarithmic demand is not so clear as the δ_D in (1.3) cannot be interpreted as a %. An alternative is to allow the % demand growth to change in the future. This would require adding (at least) two extra input boxes, first for the year when a new demand growth rate will be implemented, and second for the new demand growth rate.

2.1.4 Assumption: The link between utilization and labour demand- the production function

Constant returns

The utilization model of demand in (3.1.1) assumes a simple relationship between utilization and labour demand (workforce requirements) that implies a specific relationship between health professionals hours worked and the number of services provided (their production function): it assumes *constant returns* to additional health professionals – that each additional health professional will produce an equal additional amount of activity (or utilization). Production functions used in economics often imply *diminishing returns* to factor inputs: the more health professionals then the lower their additional contribution to productivity. However, the production function relevant for predicting future labour demand for health professionals should represent the *long term* relationship between the input of health professionals and activity produced. In the long-term context, *constant returns* may be more plausible.

It is possible to obtain data on health labour force productivity in Australia. Scott (2006) uses AIHW and Medicare data to calculate a time series of utilization (services provided) per GP and per specialist. The paper finds this measure of productivity was falling between 1997 and 2003 but that this was probably due to a decrease in hours worked – a change in the labour input – rather than a fall in productivity in terms of utilization per hour of labour.

Possible bias caused by assuming constant returns

Where there is some degree of diminishing returns, additional health professionals may produce less additional output than current health professionals. The model would underestimate the additional health professionals required to produce the level of utilization demanded by patients.

Possible changes to HWPT

Recommend routine sensitivity analysis of workload measures.

2.1.5 Assumption: No labour substitution

Another production issue the model ignores in its current form is labour substitution. If we predict a certain utilization increase into the future, the model assumes this will translate into a similar increase in demand for the healthcare professionals' labour (according to β_{st} and β_{ct} in (3.1.1)). However, this prediction will not be accurate if there will be substitution between the health professional of interest and other health professionals time (eg doctors vs nurses) in the future. In some areas of healthcare, labour substitution in the future may be predictable to some extent, for example, in primary care there is a trend of substitution in production towards nurses and away from doctors. Labour substitution of this type necessitates combining the workforce planning models for closely related workforces (eg practice nurses and GPs).

Possible bias caused by assuming no labour substitution

The bias could go be in either direction. In the doctors and nurses in primary care example, the model would underestimate requirements for nurses and overestimate requirements for GPs.

Possible changes to HWPT

Recommend routine sensitivity analysis of supply

2.2 Assumptions about supply

2.2.1 Description of supply model

Equation (1.5) describes the supply of labour hours S_t in the HWPT model in year t. Labour hours supplied are determined by the number of male and female health professionals at time t in each age group *g*. The age groups *g* can be either 5-year or 1-year age groups. The coefficients $\beta_{g,male}$ and $\beta_{g,female}$ represent the number of hours worked by male and female health professionals in age group *g*.

$$S_t = \sum_g \left[\beta_{g,male} male_{tg} + \beta_{g,female} female_{tg} \right] \qquad (1.5)$$

Changes in supply over time are included in the HWPT model as shown in equations (1.6) and (1.7)

$$male_{tg} = \left(1 - \beta_{g,male}^{loss}\right) male_{t-1,g} + malegrads_{tg} + malemigrants_{tg} \qquad (1.6)$$

$$female_{tg} = \left(1 - \beta_{g,female}^{loss}\right) female_{t-1,g} + femalegrads_{tg} + femalemigrants_{tg} \qquad (1.7)$$

For both males and females, each age group loses a proportion of the workforce every year: $\beta_{g,male}^{loss}$ and $\beta_{g,female}^{loss}$. Net of the losses, the workforce grows by the number of graduates ($malegrads_{tg}$ and $femalegrads_{tg}$) and migrants ($malemigrants_{tg}$ $femalemigrants_{tg}$) in each age group entering the workforce in each year. The change in numbers of the workforce is converted into the amount of labour hours supplied according to the coefficients in equation (1.5).

Many of the assumptions underlying the supply-side of the model are related to uncertainty arising from the source and the quality of the data used. These are examined in section 4 (Sensitivity Analysis).

2.2.2 Assumption: No changes in technology

The relationship between health professional hours and the number and mix of services provided (the production function) implied by the HWPT model assumes no change in medical technology in the future. Improving medical technology can have two effects on the supply of services and future utilization: (1) existing medical procedures are performed more efficiently (with less time input from health professionals, (2) new medical procedures can be performed and existing medical procedures can be performed with higher quality. The latter effect is one of the main causes of growth in utilization and medical expenditure, and is already reflected in the assumed growth rate of utilization. This assumed growth rate may however underestimate the future positive effect of improving technology on the supply of services.

Possible bias by assuming no technology change

If technology improves in the future increasing efficiency of production, this assumption would mean the model overestimates the requirements for health professional labour. If the increase in technology introduces new medical procedures in the future *more than is already represented in the assumed increase in utilization,* this assumption would mean the model underestimates the requirements for health professional labour. The two effects work in opposite directions.

Possible changes to HWPT

Recommend routine sensitivity analysis of utilisation growth.

2.2.3 Assumption: Disaggregation only by age and sex

The supply side of the model has a simple stock and flow approach to the number of workers entering and leaving the workforce and also includes a model of hours worked by different groups of workers. The main assumption of this approach is that the entrant/exits to the workforce and hours worked are disaggregated by age and sex groups. This imposes some restrictions. One is that immigrant workers (in a given age and sex group) are assumed to have the same exit probability and working hours as non-immigrant workers. This might be a significant restriction if we expect migrant workers to have different average working hours or probability of leaving the workforce. The latter is especially likely – a proportion of immigrant workers are likely to exit the workforce to return to their home country.

Possible bias by disaggregation only by age and sex

Taking the immigrant workers example, if part of the growth of workforce is assumed to come from immigration, current exit rates may underestimate the propensity for these workers to leave the workforce. This would lead to an overestimate of workforce supply and an underestimate of the number of training places needed to balance supply and demand.

Possible changes to model

Allow different exit rates and hours worked for immigrant workers. This would be another dimension of disaggregation, so the model would be disaggregated by age groups, sex and migration status (Australian or immigrant).

3 Sensitivity analysis

There are number of methods of sensitivity analysis used in economic and decision-analytic models[1]. These account for the inherent uncertainty in the data. We use data from the PwC macro-modelling project[2] to conduct *one-way sensitivity analysis*. This is where one assumption is changed at a time, and the effect of this change on projected workforce requirements is evaluated. Data from radiographers (sections 4.1 to 4.3) is used, as well data for doctors (sections 4.4 to 4.6).

Other types of sensitivity analysis are beyond the scope of this report as they require specific assumptions about future scenarios (*multi-way sensitivity analysis*) or they require stochastic data with a sampling distribution (probabilistic sensitivity analysis). For specific workforces, multi-way sensitivity analysis is already conducted by using expert groups to construct future demand and supply scenarios that can then be used to change the parameters of the model. Probabilistic sensitivity analysis requires not only a different type of data than is currently used, but more complex modelling expertise. The statistical distributions of parameters can also be simulated using Monte Carlo simulation (see Joyce et al (2007) for an example for GPs in Australia).[3]

3.1 Summary of existing model for radiographers

We used data from the 2009 Macro Modelling project for radiographers for the sensitivity analysis. Some of the key assumptions and results from the model are given in Tables 1 and 2.

Table 1: Key assumptions for the Radiography example

Demand* growth (%)	FTE Demand in 2006	FTE shortage in base year (2006)	University drop out rate (%)	Balancing year	Existing graduates per year	Mean exit rate (females aged 23-70)	Retirement age
4.4	10148	0	20	2030	1000	0.047	70

*Note this is a linear trend expressed as a % of the demand in year 2006

The demand growth rate is 4.4% of 10148 (=446.5) and supply is equal to demand (no shortage) in the base year. As is common to all the projections in the Macro Modelling report, the linear demand growth rate (derived from data outside the model) is simply applied to FTE radiographers. Apart from the assumptions in Table 1 the model also has exit rates and working hours for the workforce by age and sex groups. The model also assumes the training time is 4 years and that new training places start in 2009.

The results in Table 2 show that demand nearly doubles (to 20864 FTE) in the 24 year period to 2030 and that there is a 20.5% gap between demand and supply. Balancing the model by a one-off increase in training places in 2009 produces 473 training places (assuming a 20% graduate drop-out rate).

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[1] Briggs A.(2001) Handling uncertainty in economic evaluation and presenting results. In: Drummond MF and McGuire A. Economic Evaluation in Health Care. Merging Theory with Practice. Oxford University Press and Office of Health Economics: Oxford.

[2] PricewaterhouseCoopers (2009) Project 1: Updating Macro Supply and Demand Model. National Health Workforce Taskforce.

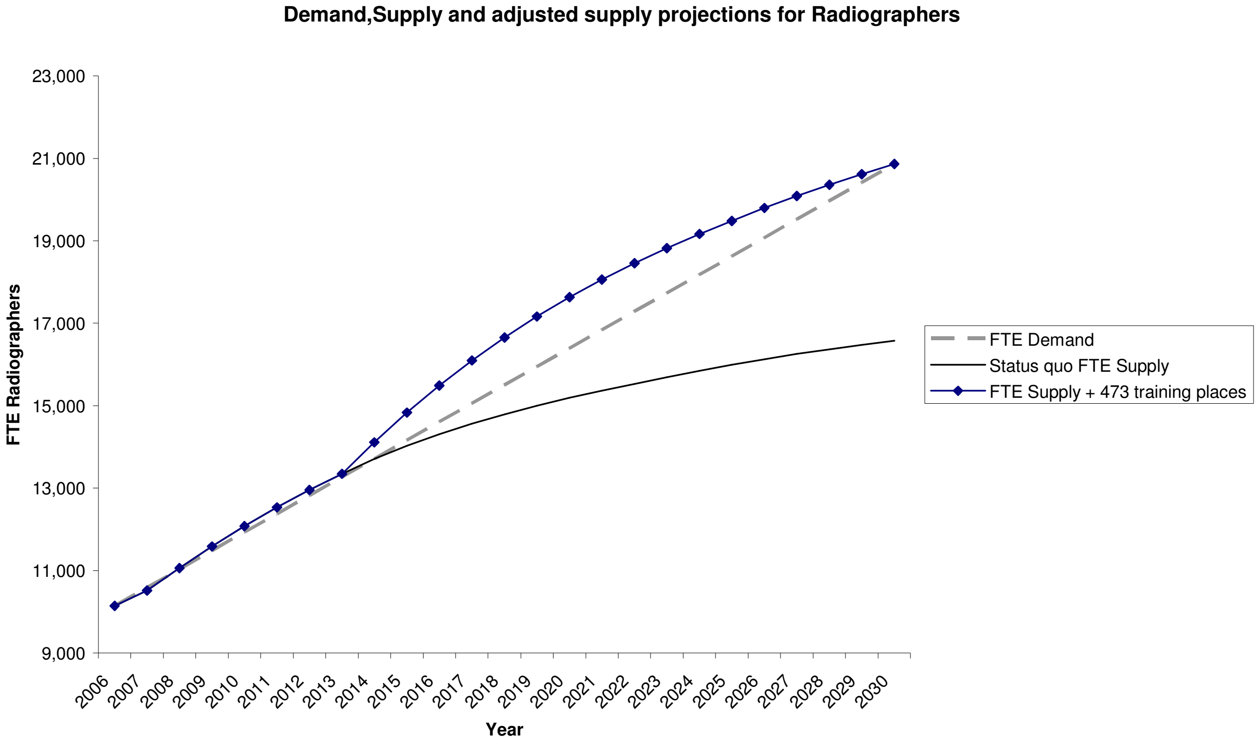
[3] Joyce C., McNeil JJ., Stoelwinder JU. (2006) More doctors, but not enough: Australian medical workforce supply 2001–2012. Medical Journal of Australia, 184, 441-446.

Table 2: Key results for the Radiography example

Predicted FTE demand in 2030	Predicted FTE Supply in 2030	Predicted FTE gap (%) in 2030	Graduates required	Recommended extra training places in 2009
20864	16578	20.5	378	473

Figure 2 shows that the status quo FTE supply grows at a decreasing rate causing the gap between demand and supply by 2030. Supply grows at a decreasing rate because of the fixed exit rates, so that the number of exits increases year-on year as supply grows whereas the number of entrants (graduates) remains fixed. The chart also indicates the supply after balancing the model. We can see adding extra training places in 2009 produces graduates in 2013 where the supply function pivots upwards. Supply is equal to demand in 2030 but we can see supply significantly exceeds demand for most of the period between 2013 and 2030. The excess supply is due to the curvature of the supply function caused by the fixed exit rates.

Figure 2.



Comparing this example with the other models in the Macro Modeling report we note that for the doctors and nurses models, the supply curve is noticeably less curved and an excess supply is not observed to the same extent as for radiographers. This seems to be due to several differences in the doctors and nurses models including growth in graduate numbers for the first five years of the period, a slightly shorter time period (balance in 2025), a shortage in the starting year, lower demand growth and a smaller (relative) FTE shortage in the balancing year. The following sensitivity analysis (for radiographers) is repeated for doctors in sections 4.4 to 4.6.

3.2 Sensitivity analysis of demand assumptions for radiographers

We present a sensitivity analysis of the rate of demand growth for the radiography example, increasing and decreasing demand by 0.1 percentage point and 1 percentage point. Because of the incompleteness in the utilisation data used to derive the demand growth rates, it is plausible that the Medicare data used to derive the demand growth estimates is inaccurate to this degree. We present the number of training places recommended by balancing model in these different scenarios. The results of the sensitivity analysis are presented in Table 3 and the different demand assumptions illustrated in Figure 3.

Figure 3.

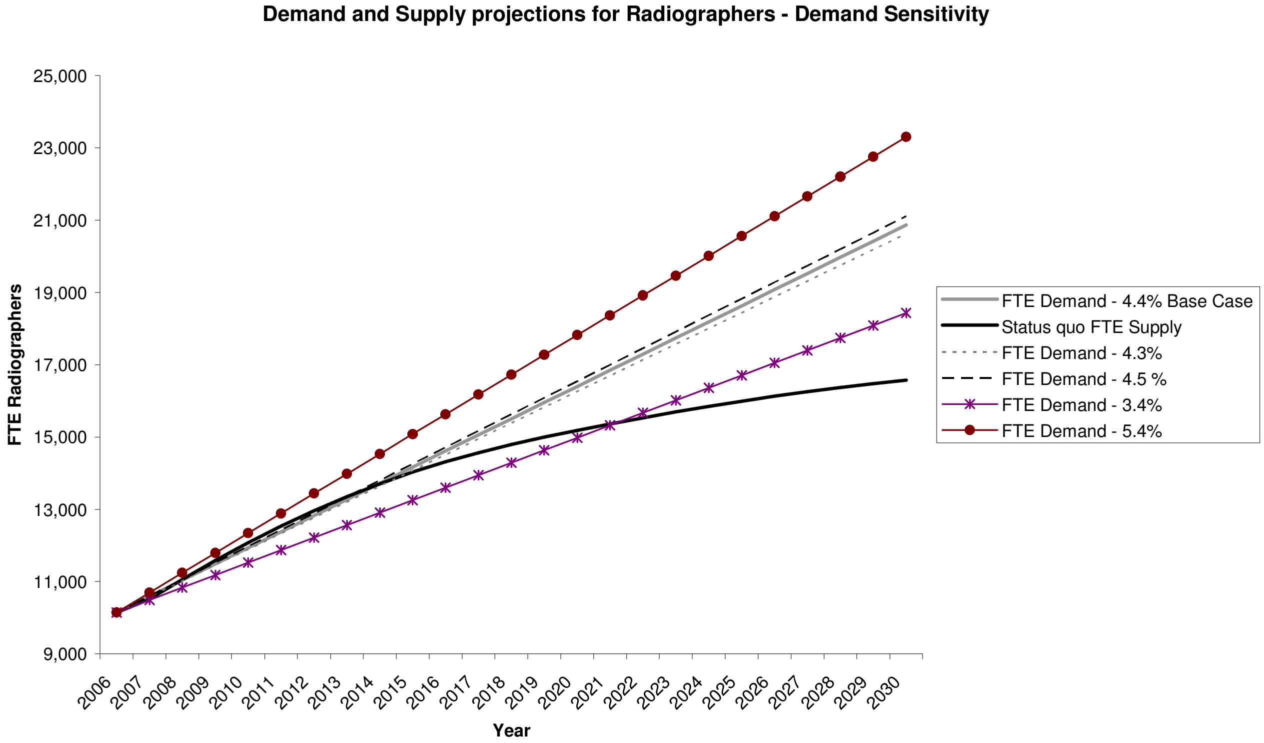


Table 3. Sensitivity analysis of demand growth

Assumed demand* growth	Difference from base case	Predicted FTE demand in 2030	Predicted FTE gap (%) in 2030	Recommended extra training places in 2009
3.4	-1	18429	10.0	204
4.3	-0.1	20621	19.6	446
4.4	0	20864	20.5	473
4.5	+0.1	21108	21.5	499
5.4	+1	23300	28.9	741

*Note this is a linear trend expressed as a % of the demand in year 2006

The results show the plausible changes in the demand assumptions have a relatively large effect on the number of training places needed to balance the model. The difference between a demand of 3.4% and 5.4% is over 500 training places and even an increase in demand of 0.1% produces over 20 extra training places.

3.3 Sensitivity analysis of supply assumptions for radiographers

3.3.1 University drop out rates

One of the simplest assumptions is the university drop-out rate which is used to translate the graduates required into training places. For the radiography example this rate is set at 20% based on 5 years of university admissions and completions data. Table 4 presents the changes in training places as the drop-out rate is varied by 1 percentage point or 5 percentage points in each direction.

Table 4. Effect of changing the University drop out rate

University drop-out rate (%)	Difference from base case	Recommended extra training places in 2009
15	-5	445
19	-1	467
20	*0*	*472*
21	+1	478
25	+5	504

The results show the reasonable changes in the drop out rate have a relatively modest effect on the training places recommended. The number of training places changes by just over 10% (504 to 445) if we consider a 10 percentage point change in the drop out rate (25% to 15%).

3.3.2 Exits from the workforce

In the macro modelling report, age and sex specific exit rates are calculated by comparing census data between 2001 and 2006. We tested the sensitivity of the exit rate assumption by running the model with slightly lower or higher exit rates: reduced/increased by 1 percentage point. Figure 4 illustrates the distribution of exit rates in the base case and the two scenarios with different exit rates.

Table 5 shows the effect of changing the exit rate assumption on the predicted FTE supply and the recommended training places needed to balance the model in the two different scenarios.

Table 5. Effect of changing age-sex specific exit rates

Change in assumed exit rate	Mean exit rate (females aged 23-70)	Predicted FTE supply in 2030	Predicted FTE gap (%) in 2030	Recommended extra training places in 2009
+0.01	0.057	14,892	29.6	697
Base case	0.047	16,578	20.5	473
-0.01	0.037	18,584	10.9	237

The results show reducing the exit rates by even 0.01 percentage points has a large impact on the model, increasing predicted supply in 2030 by over 2000 FTE radiographers. This increase in supply reduces the gap between demand and supply, and the recommended training places by half. In an almost linear fashion, increasing exit rates *increases* the gap between supply and demand by about 50%. Figure 5 illustrates supply in the base case and the two scenarios with different exit rates.

Figure 4.

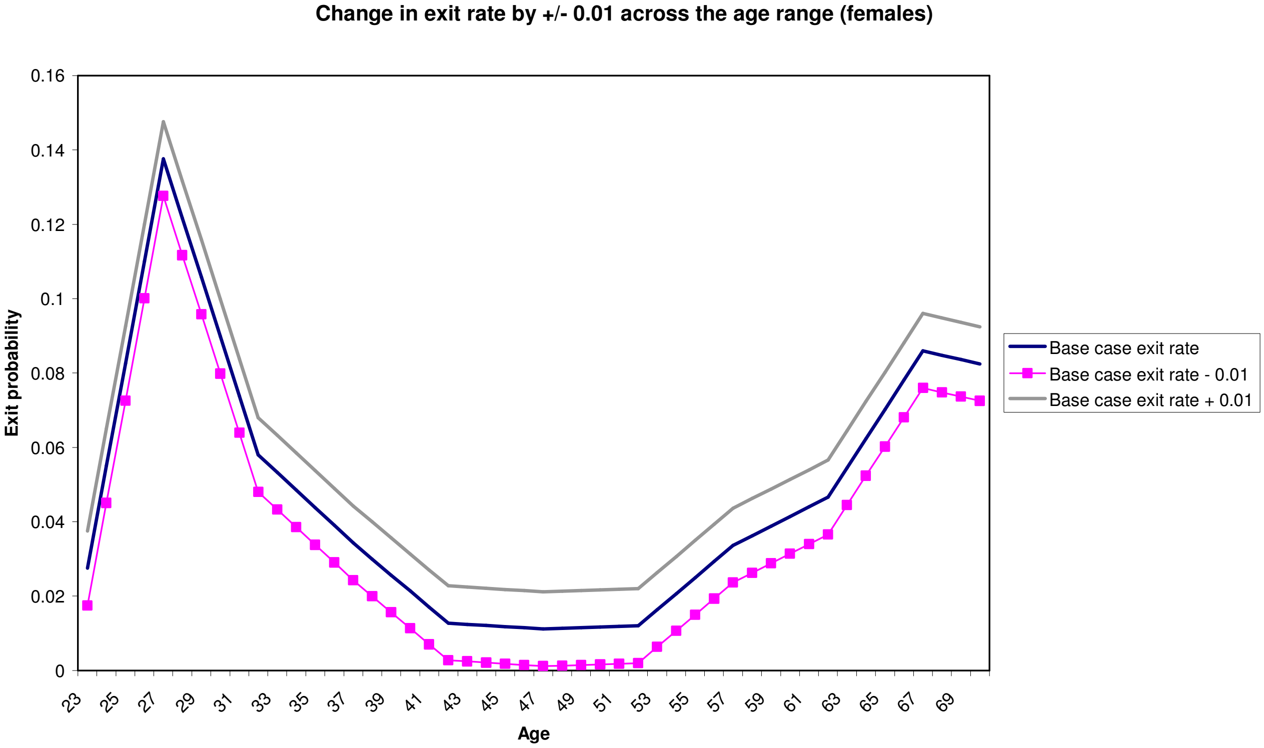


Figure 5 shows that reducing the exit rate significantly reduces the curvature of the supply function. When the exit rate is lower, the number of exits from the model grows more slowly through time, so supply increases at a faster rate. Analogously, increasing the exit rate increases the curvature of the supply function and the supply grows more slowly.

It is possible the results obtained changing the exit rate assumption were related to the way exit rates were changed across the age range. To check the robustness of these results we tested the sensitivity of the model to a proportional change in exit rates. We reduced exit rates by 20% so that the average decrease would be approximately the same as reducing by 0.01 (the base case average exit rate is 0.047). Figure 6 show the reduction in exit rates, comparing this with Figure 4 we can see the exit rate falls more for age ranges at either end of the distribution where the initial exit rate is greater than 0.06, but only falls slightly for the age range 43 to 53 where the initial exit rate is less than 0.02.

The results are given in Table 6, where the average exit rate is reduced by the same amount as for an absolute reduction of 0.01 (as in Table 5). The effect on the gap between supply and demand in 2030 and on the recommended training places is similar, although slightly smaller than for the absolute reduction in exit rates.

Figure 5.

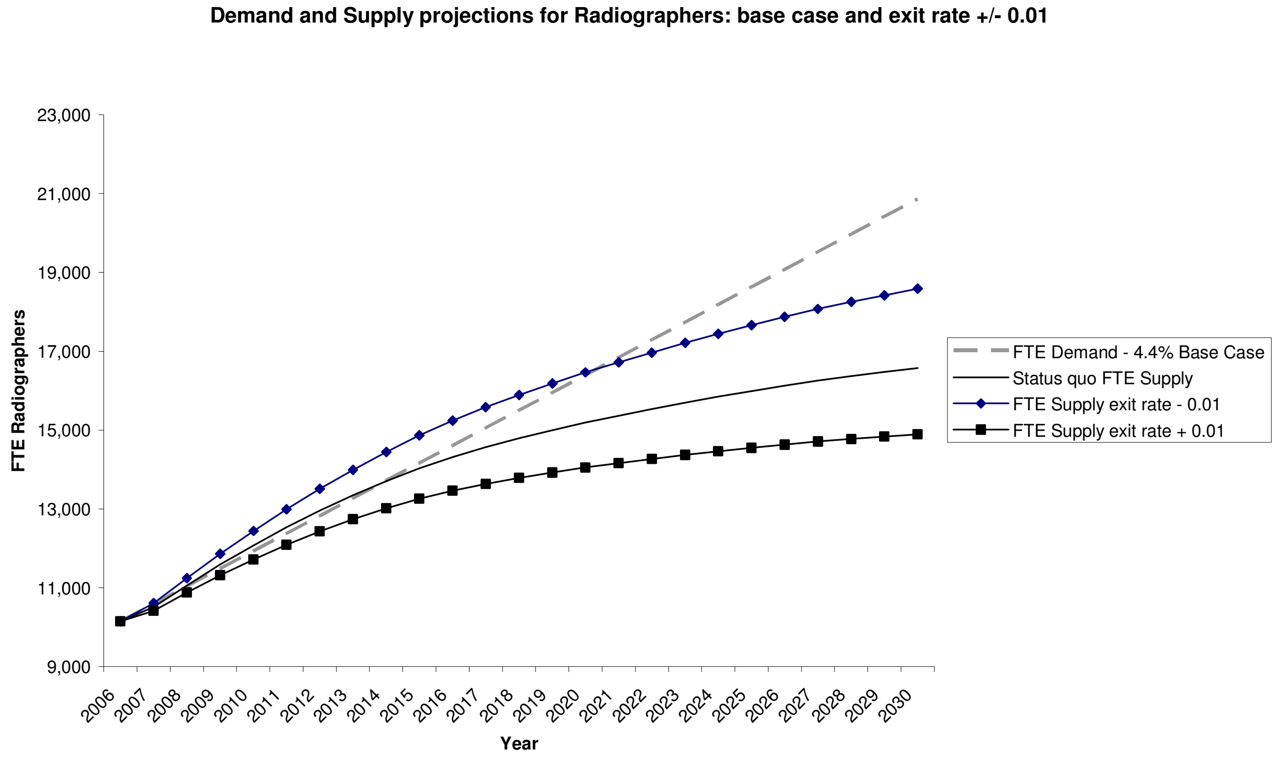


Figure 6.

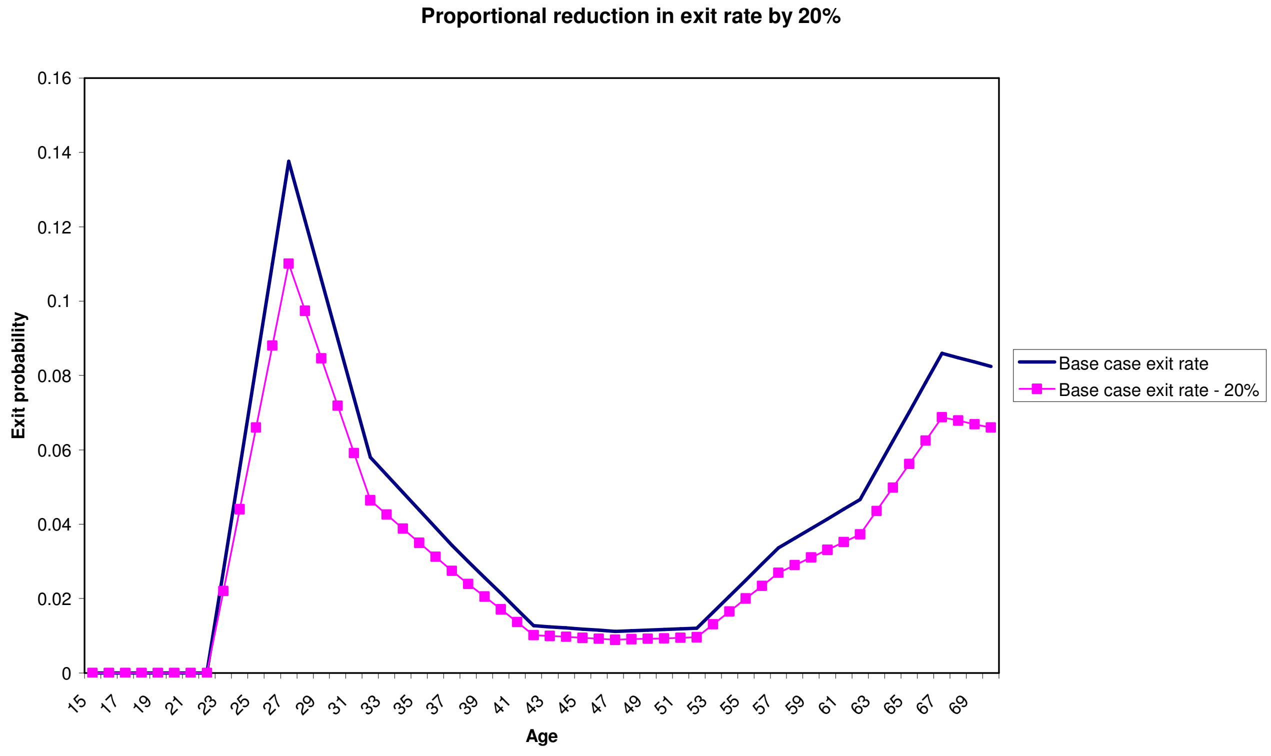


Table 6. Proportional change in age-sex specific exit rates

Change in assumed exit rate	Mean exit rate (females aged 23-70)	Predicted FTE supply in 2030	Predicted FTE gap (%) in 2030	Recommended extra training places in 2009
Base case	0.047	16,578	20.5	473
-20%	0.037	18,394	11.8	254

3.3.3 Exits from the workforce: retirement age

An important part of the model is the exits from the workforce. One important element of this might be the retirement age: when the probability of exit becomes equal to 1. In the radiography example, the retirement age is set at 70. This seems relatively high so we consider scenarios in which the retirement age is 68 and 65. Table 7 presents the results of the base case and the two different scenarios.

Table 7. Effect of changing the retirement age

Assumed retirement age	Difference from base case (years)	Predicted FTE supply in 2030	Predicted FTE gap (%) in 2030	Recommended extra training places in 2009
70	0	16,578	20.5	473
68	-2	16,474	21.0	484
65	-5	16,291	21.9	505

The results show reducing the retirement age by 2 or 5 years reduces predicted FTE supply in 2030 by 104 or 287 FTE radiographers. This translates into an extra 11 or 32 training places per year. These results therefore show that the retirement age has a relatively modest effect on recommended training places. It is important to note that the age-sex specific exit rates will include those who retire before the age of 70, but these are not disaggregated from the overall exit rate.

3.3.4 Balancing assumptions

Graduate growth rate

The model balances supply and demand in a given year in the future by increasing the number of training places (and graduates) in a given year before the balancing year. The increase in training places used to balance the model is a ‘one-off’ increase. An alternative is to balance the model by introducing a growth rate for graduates and training places. This might be more realistic because historical patterns show gradual increases in the number of training places in universities. In the Macro Modeling report, the allied health workforces are all assumed to have no underlying growth in training places in the future, whereas the nurses and doctors models allow for some growth in the number of graduates in the first years of the projection.

We run the model for the radiographers example, allowing for a growth rate of 10 graduates per year and 20 graduates per year and compare the results with the base case. Table 8 shows the results.

Table 8. Changing the growth rates of graduates in each year

Growth of graduates per year	Equivalent growth of training places per year	Predicted FTE supply in 2030	Predicted FTE gap (%) in 2030	Recommended extra training places in 2009
Base case - 0	0	16578	20.5	473
10	13	18548	11.1	255
20	25	20518	1.6	38

The results show that introducing a growth rate of 10 or 20 graduates per year increases the FTE supply by 2030 by 2000 or 4000 radiographers. This increase in supply reduced the FTE gap to almost zero for the 20 graduate growth rate. Figure 7 graphs the base case and the two alternative scenarios with graduate growth rates.

Figure 7

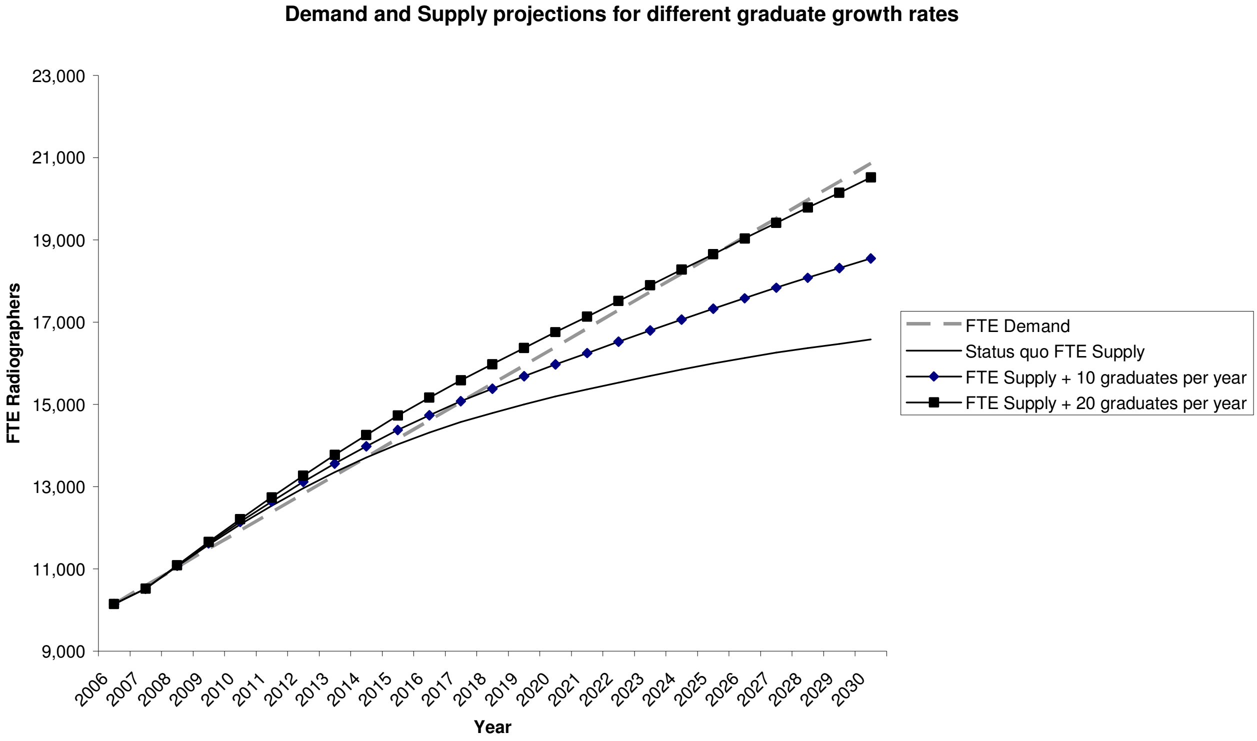
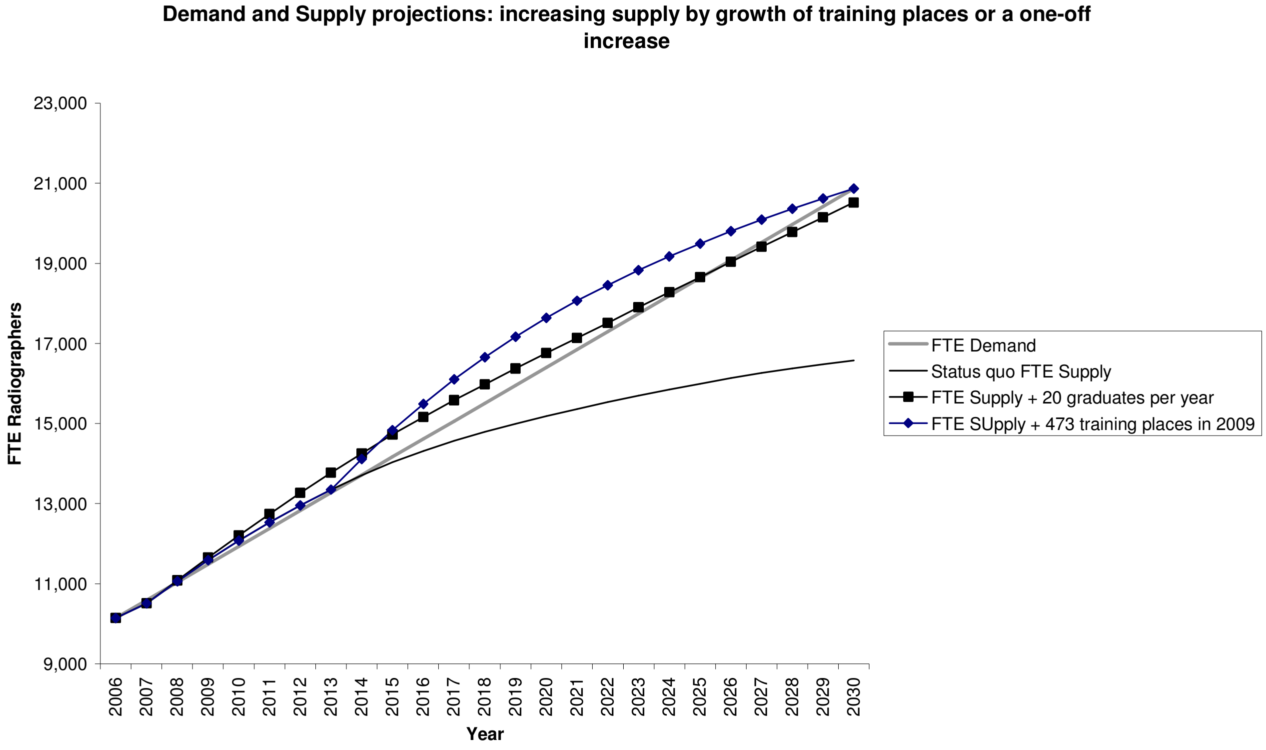


Figure 8 compares the graduate growth rate of 20 to the FTE supply in the ‘balanced’ version of the model when 473 training places are introduced in 2009. The chart shows there are some advantages to increasing the number of graduates gradually with a growth rate, rather than balancing the model with a one-off increase in training places. Firstly, the one-off increase in training places causes a large excess supply for the time period 2013 to 2030. The excess supply is smaller in the graduate growth rate case. Secondly, the growth rate in graduate supply brings the growth of FTE supply more into equilibrium with the linear growth in demand – we can see from the chart the slope of FTE supply is much closer to the slope of FTE demand in the graduate growth rate case.

Figure 8.


Demand and Supply projections: increasing supply by growth of training places or a one-off increase

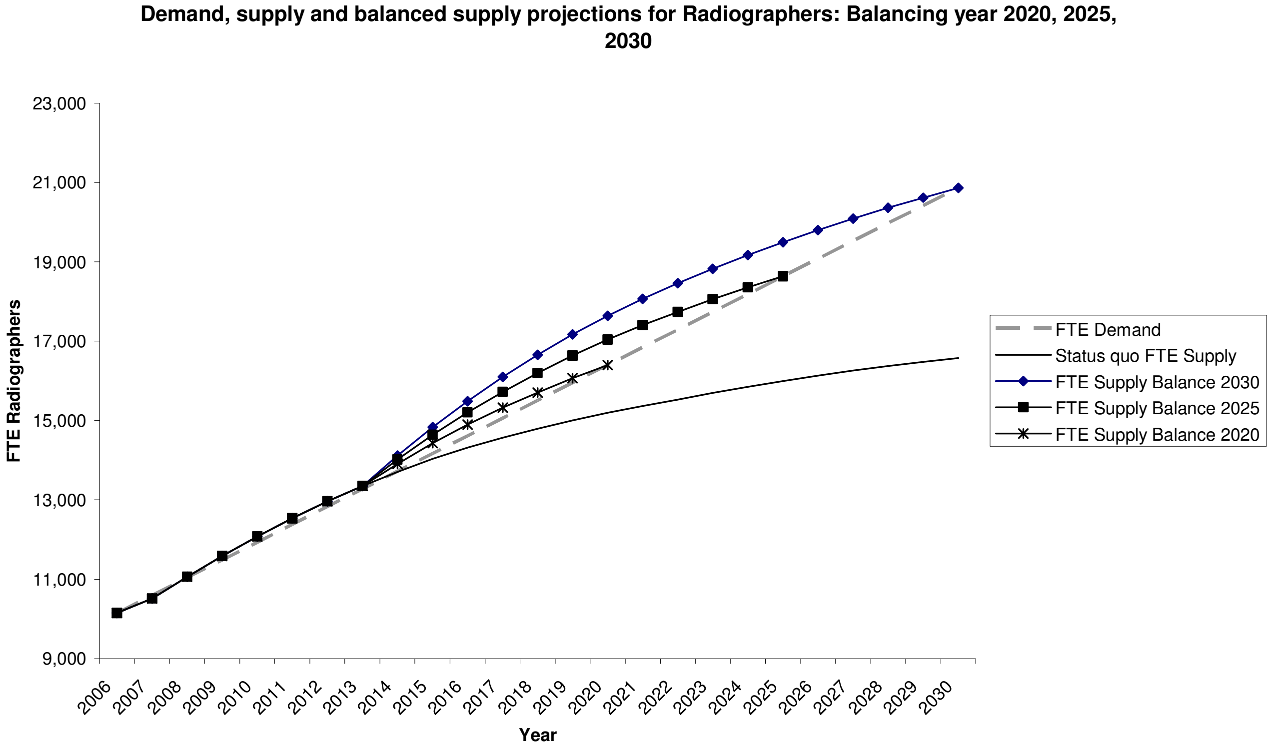
Balancing year

The year used to balance the model is arbitrary and it affects the projected workforce requirements. Policymakers would prefer health workforce policies that balance supply and demand in the medium and long-term rather than at one particular date. We run the model for radiographers under two alternative scenarios: where the balancing year is 5 years and 10 years earlier than in the base case in 2025 and 2020. The results are shown in Table 9. The results show that an earlier balancing year reduces the predicted FTE gap between supply and demand. The gap is reduced by 5.6% by changing the balancing year to 2025, and is reduced by a further 7.5% by changing the balancing year to 2020. Figure 9 plots the FTE supply after balancing when the balancing year is 2020, 2025 and 2030.

Table 9. Effect of changes in the balancing year

Balancing year	Predicted FTE Demand in Balancing year	Predicted FTE supply in balancing year	Predicted FTE gap (%) in balancing year	Recommended extra training places in 2009
Base case - 2030	20864	16578	20.5	473
2025	18632	15992	14.9	357
2020	16399	15191	7.4	233

Figure 9


Demand, supply and balanced supply projections for Radiographers: Balancing year 2020, 2025, 2030

We can see that the balanced model produces very different results for the three balancing years because of the concave curvature of the supply function over time. We have seen previously in Figure 5 how the curvature of the supply function is related to exit rates and growth rates of graduates in the model.

3.4 Summary of existing model for doctors (medical workforce)

We used data from the 2009 Macro Modelling project for doctors (the medical workforce) for the sensitivity analysis. Some of the key assumptions and results from the model are given in Tables 10 and 11.

Table 10: Key assumptions for the medical workforce example

Demand* growth (%)	FTE Demand in 2007	FTE shortage in base year (2007)	University drop out rate (%)	Balancing year	Existing graduates per year	Mean exit rate (females/males aged 25-70)	Retirement age
2.2	75236	4500 (7%)	2	2025	2243 (2007) to 2920 (2012-)	0.067/0.032	75

*Note this is a linear trend expressed as a % of the demand in year 2006

There are some substantial differences between the assumptions for the medical workforce and those for the previous radiographers example. The most significant relate to the size of the workforce, the initial shortage in the base year and the existing growth in graduates per year. The medical workforce is 70736 in 2007, nearly 7 times the size of the Radiography workforce. This means that when comparing the models, the numbers (eg of required training places) associated with the medical workforce are much larger and so we concentrate on proportional measures (eg the % gap between supply and demand) to enable fair comparisons. The assumption of an initial shortage of 4.5% means demand doesn't need to grow faster than supply to generate a shortage in the balancing year. The growth in the existing graduates for the first 5 years means that the rate of growth of supply is increasing between 2008 and 2013.

The medical workforce model also includes immigration (constant at 1500 doctors per year) which affects the rate of growth of supply. Many more graduates would be required if immigration was assumed to be zero (as in the radiographers model). The other difference between the radiographers and medical workforce examples is that the latter has a 6-year shorter projection period, starting in 2007 instead of 2006 and with the balancing year 2025 instead of 2030.

Table 11: Key results for the medical workforce example

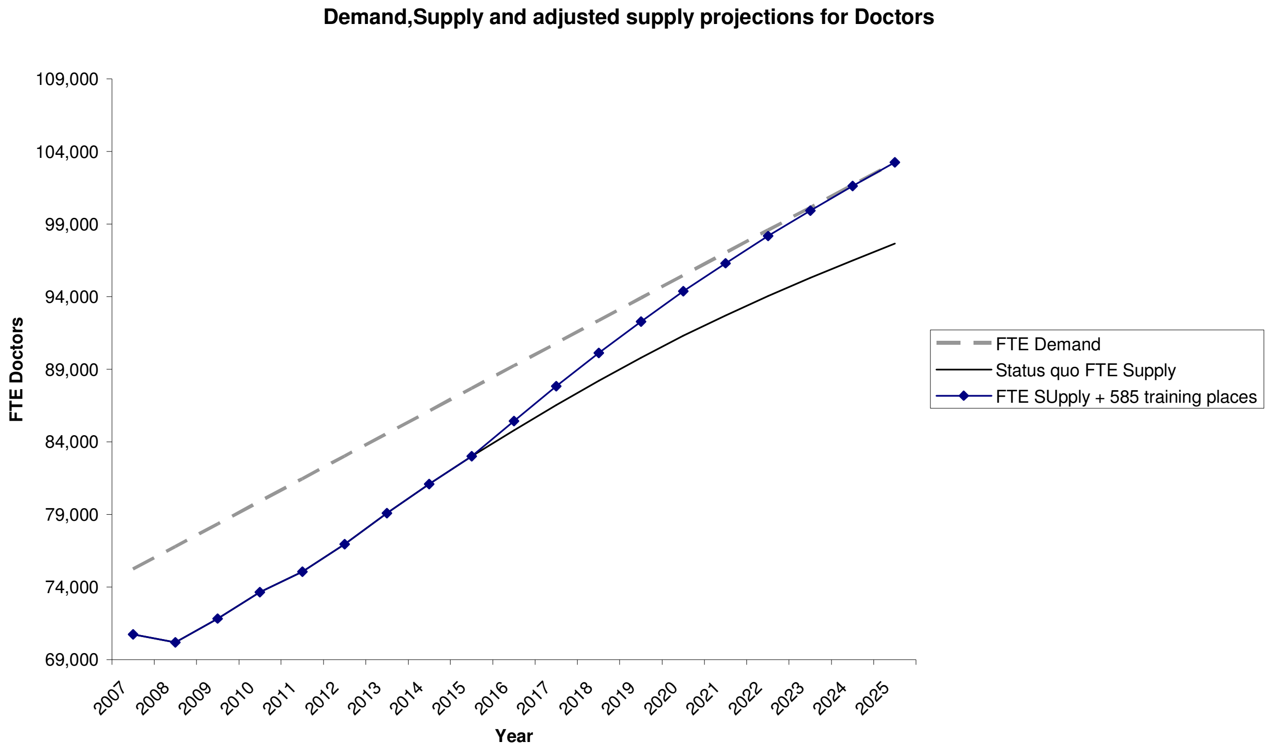
Predicted FTE demand in 2025	Predicted FTE Supply in 2025	Predicted FTE gap (%) in 2025	Extra graduates required in 2015	Recommended extra training places in 2010
103247	97653	5.73	573	585

Table 11 shows the main results for the medical workforce. Demand for doctors grows by 37% between 2007 and 2025 and the predicted gap between supply and demand is 5.7 % in 2025, not much larger than the shortage in 2007 (4.5%). The gap, and the corresponding extra recommended training places (585, assuming a university drop-out rate of 2%) is relatively small compared to the radiographers model, where the gap in 2030 was over 20%.

The balancing of the model is illustrated in Figure 10. We can see the balanced supply forecast pivots up in 2015 when the extra graduates begin to enter the workforce. In contrast to the radiographers model, there is no 'excess supply' evident in the balanced model before the balancing year. This seems to be due to the assumption of a shortage in the initial year and the shape of the supply curve which is less concave than in the radiographers example.

A feature of the medical workforce model illustrated in the graph is how the retirement age (75) causes an initial reduction in supply in the first year. This is because a (very small) proportion of doctors in the workforce are over the retirement age at the beginning of the model and they are all forcibly ‘retired’ in the first year of the model.

Figure 10



3.5 Sensitivity analysis of demand assumptions for doctors

We use the same basic sensitivity analysis for demand as for the radiographers example, varying demand by 0.1% and 1% in either direction. Figure 11 illustrates the different demand assumptions and Table 12 presents the results.

Table 12.Senstitivity analysis for medical workforce example

Assumed demand* growth	Difference from base case	Predicted FTE demand in 2030	Predicted FTE gap (%) in 2030	Recommended training places
1.2	-1	90,515	-7.31	0
2.1	-0.1	101,974	4.42	452
2.2	0	103,247	5.72	584
2.3	0.1	104,521	7.03	718
3.2	1	115,980	18.8	1916

*Note this is a linear trend expressed as a % of the demand in year 2006

Figure 11.

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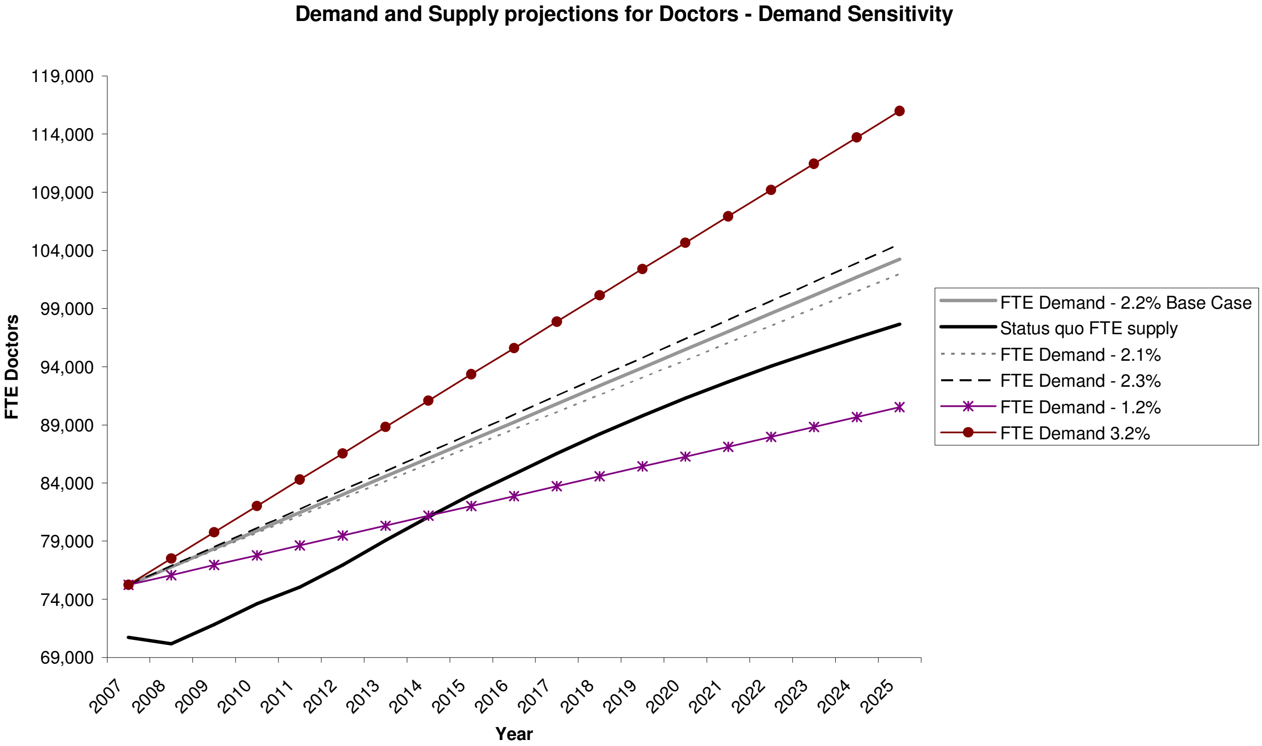


In absolute terms, we can see that varying demand by 0.1% or 1% has significant impacts on extra training places required (+/- over 100 or over 1000 training place respectively). Proportionally, the changes in demand growth have a similar but slightly larger effect on the percentage FTE gap, in comparison to results from the radiographers example. Increasing demand growth by 0.1% increases the FTE gap by 1.3% for doctors, but only by 1% for radiographers (comparing Table 3 and Table 12). We can see that the effects on predicted supply of changing the demand growth rate are approximately linear, increasing or decreasing demand growth by 0.1% or 1% has a very similar-sized effect on FTE supply.

Another feature of the demand sensitivity analysis for doctors is that a reduction of one percentage point in the growth rate of demand puts the model into a surplus (excess supply). This demonstrates how the predicted gap between supply and demand for doctors is relatively small.

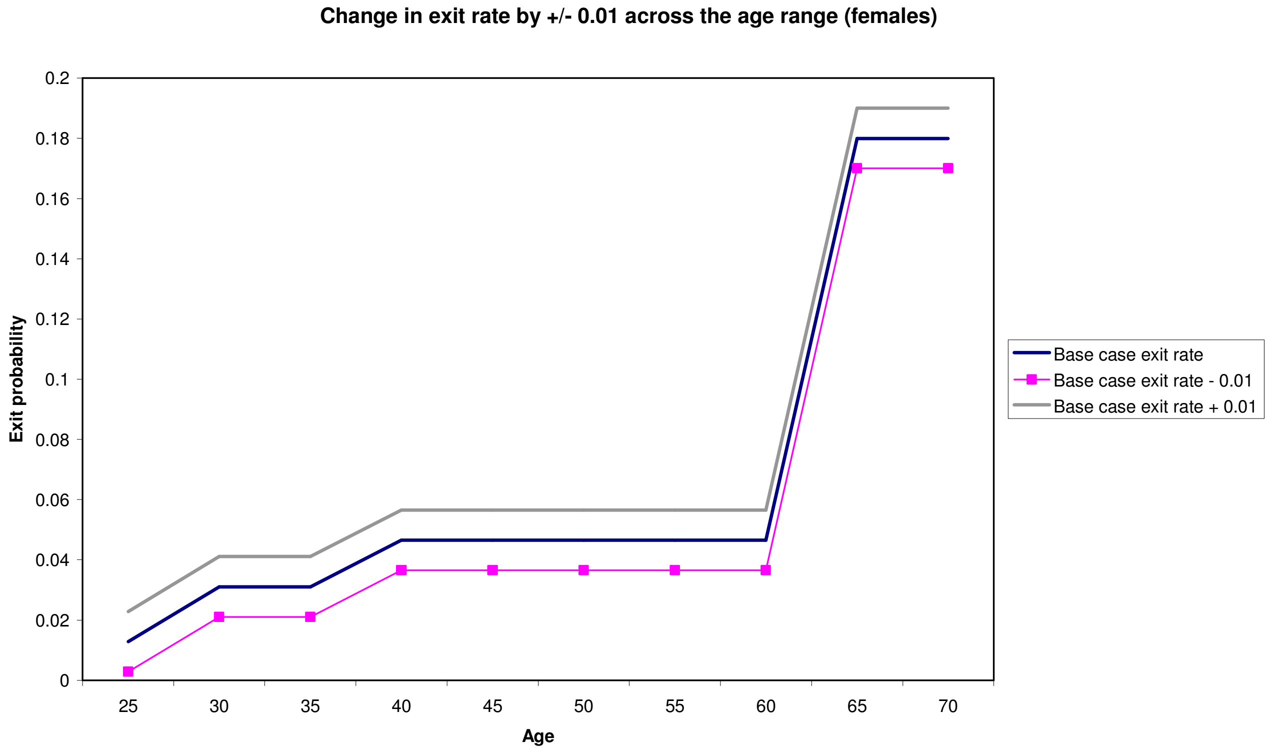
3.6 Sensitivity analysis of supply assumptions for doctors

The sensitivity analysis of exit rates for the doctors workforce is the same as for radiographers: we increase/reduce the exit rate by one percentage point over the age range for males and females.

3.6.1 Exits from the workforce

Changes in the exit rate distribution are illustrated in Figure 12.

Figure 12.



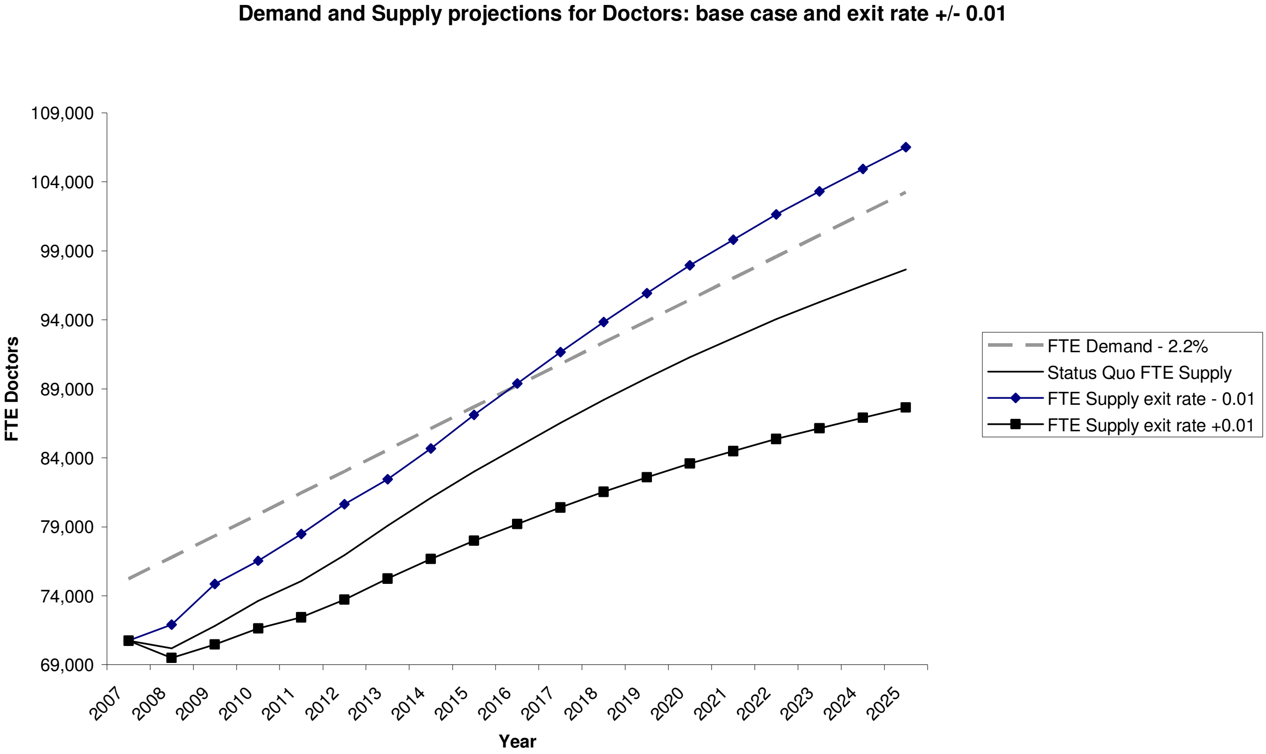
The changes in average exit rates and the results in the balanced model are shown in Table 13 and illustrated in Figure 13. In both cases, a change of one percentage point in the exit rate across age and sex subgroups corresponds to a one percentage point change in average exit rates.

Table 13. Exit rates and results

Change in assumed exit rate	Mean exit rate (males/females aged 25-70)	Predicted FTE supply in 2025	Predicted FTE gap (%) in 2025	Recommended extra training places in 2010
+0.01	0.042/0.077	87642	17.8	1701
Base Case	0.032/0.067	97653	5.7	585
-0.01	0.024/0.057	106515	-3.1 (surplus)	0

As for radiographers, changes in assumed exit rates for doctors has very substantial implications for the recommended extra training places. The effects are in the same order of magnitude (although slightly smaller) than those for a one percentage point change in demand (see Table 12). The one percentage point reduction in exit rates is sufficient to convert the predicted FTE gap between supply and demand in 2025 into a surplus, highlighting the relatively small size of the gap in the doctors model. The results also show that (unlike demand) the effect of changing exit rates on predicted future supply is nonlinear. Increasing the exit rates by one percentage point reduces supply by approximately 10000 FTE, but reducing exit rates by the same amount only increases supply by approximately 9000 FTE.

Figure 13



3.6.2 Exits from the workforce: retirement

The sensitivity analysis of retirement age is presented in Table 14. For doctors, a 5-year age-profile is used so the retirement age can only be changed in 5-year increments. We show the effects of reducing the retirement age by 5 and 10 years.

Table 14.

Assumed retirement age	Difference from base case (years)	Predicted FTE supply in 2025	Predicted FTE gap (%) in 2025	Recommended training places
75 (base case)	0	97,653	5.7	585
70	-5	96,276	7.2	729
65	-10	92,313	11.8	1144

As for radiographers, the effect of changes in the retirement age is relatively modest. The effect of a 5 year reduction in the retirement age for radiographers and for doctors has a very similar effect on the FTE gap: 1.4% and 1.5% respectively. For doctors even when we consider a 10 year reduction in the retirement age, we see that this has only about half the effect on predicted supply as a one percentage point reduction in exit rates over the age range.

3.6.3 *Balancing assumptions*

Graduate growth rate

Table 15 presents the effects of introducing growth in graduates from 2012 to 2025. Figure 14 illustrates the two scenarios: growth of 40 graduates per year and growth of 80 graduates per year.

Table 15. Introducing growth in graduates from 2012 to 2025

Growth of graduates per year (from 2012 -2025)	Equivalent growth of training places per year (2007 to 2025)	Predicted FTE supply in 2025	Predicted FTE gap (%) in 2030	Recommended extra training places (in 2010)
Base case - 0	*0*	97,653	5.7	585
40	41	100,788	2.4	257
80	82	103,935	-0.6 (surplus)	0

The results show that introducing growth of 40 graduates (41 training places) per year more than halves the gap between supply and demand in 2025 and a growth rate of 80 graduates (82 training places) per year results in a small surplus.

Figure 14 illustrates the base case and the two alternative scenarios with growth in the number of graduates between 2012 and 2025. We can see that the scenario where the number of graduates grows by 80 per year (from 2012 to 2025) makes the trend in increasing supply approximately linear where the growth of entrants (graduates) is roughly equal to the growth in exits caused by the fixed exit rates.

Figure 15 compares balancing the model with a graduate growth rate of 80 per year with the default balancing of the model (a one-off increase in training places in 2010). In contrast to the radiographers example (see Figure 8) the two methods of balancing look quite similar in this case. One reason is because the relative size of the gap between supply and demand for doctors (~5%) in 2025 is much smaller than in the radiographers model (~20%).

Figure 14.

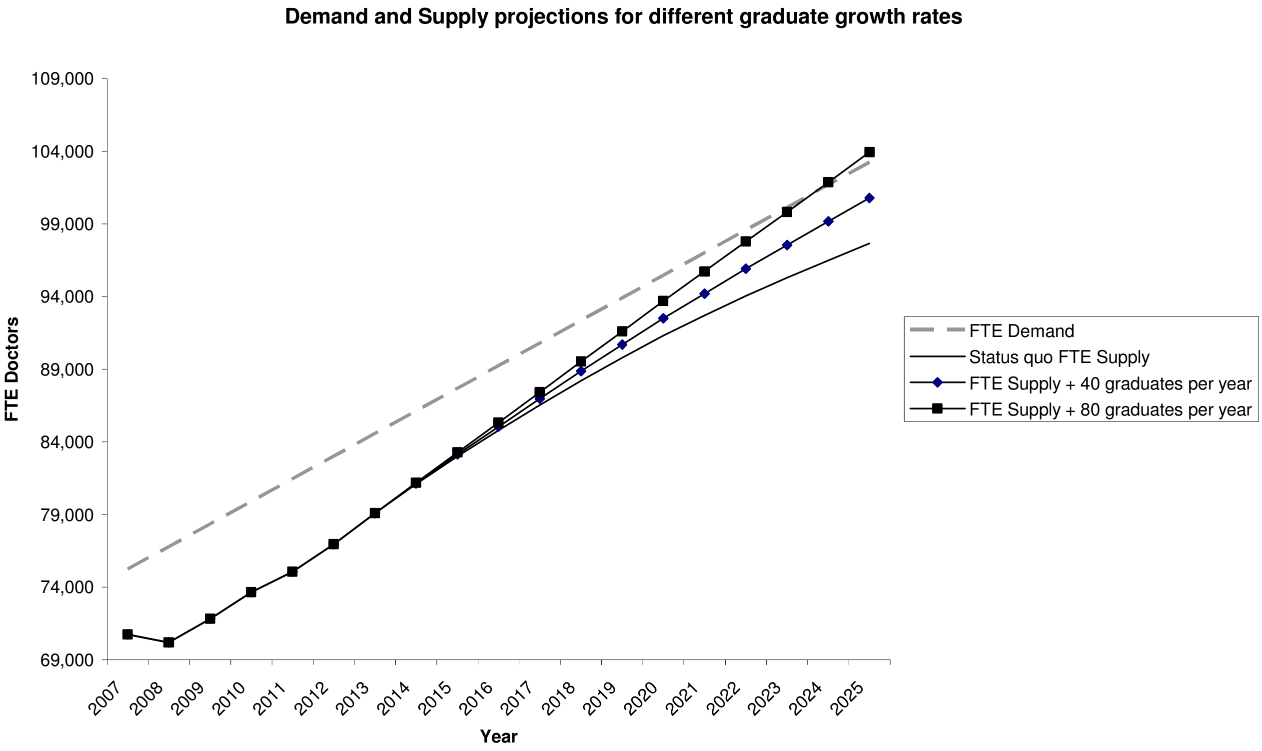
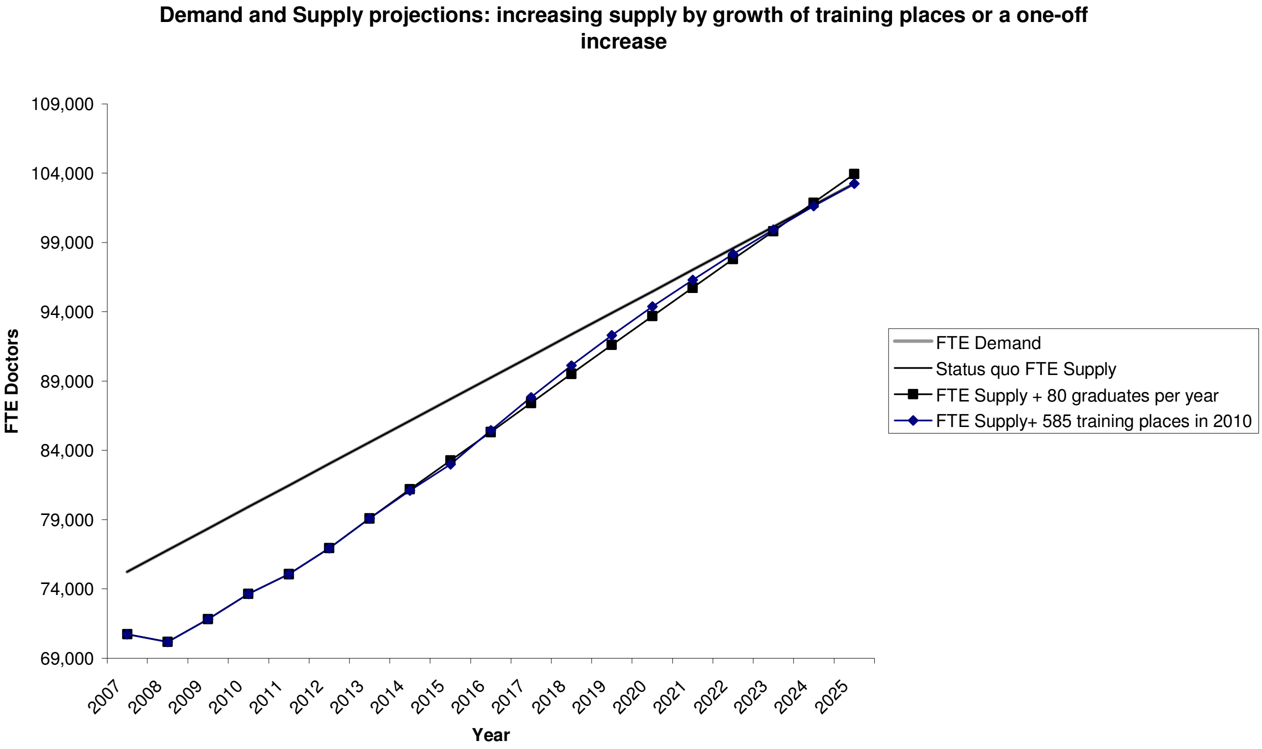


Figure 15.



Balancing year

Finally, we compare the results of the model balanced in different years. Table 16 presents the results of balancing 5 years later (2030) and 5 years earlier (2020).

Table 16 Alternative balancing years: earlier vs. later

Balancing year	Predicted FTE Demand in Balancing year	Predicted FTE supply in balancing year	Predicted FTE gap (%) in balancing year	Recommended extra training places (in 2010)
Base case – 2025	103,247	97,653	5.7	585
2030	111,028	102,626	8.2	629
2020	95,467	91,305	4.6	796

Figure 16.

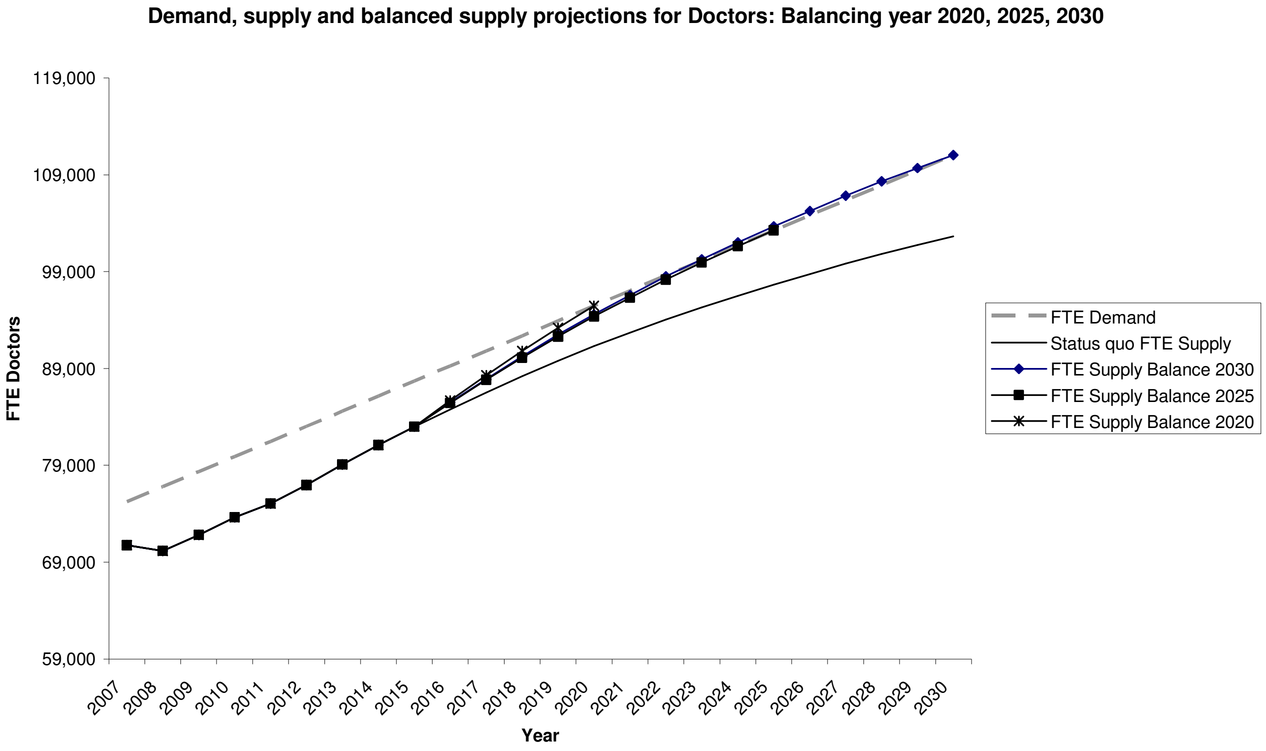


Figure 16 illustrates the results. Balancing in either 2020 or 2030 gives larger training requirements than balancing in 2025, both for different reasons. Balancing in 2020 leaves less time for the increased number of graduates to enter the workforce (they only start entering in 2015), so the initial increase in training places has to be larger to give a steeper rise in supply. Balancing in 2030 shows the effect of the exit rates, the growing workforce has a larger number of exits per year in 2030 than 2025 so a larger increase in training places is required. The fact that balancing in 2025 has the lowest training places requirements is dependent on the assumptions in the model: especially exit rates and demand growth.

4 The Interaction of Demand and Supply

The HWPT assumes no interaction between demand and supply. It assumes they are not linked through the market mechanism. The HWPT model assumes future increases in demand are independent of current increases supply. This is a significant assumption because basic economic theory predicts that demand and supply interact in the market though the price mechanism.

Consider the example of a large increase in health professional supply in the future. The market mechanism would predict the price for services provided by these professionals will fall and demand will increase. This example may not at first seem valid because in Australia (and most advanced economies) the market for health professional services is highly regulated and is not a free market with a variable price. However, prices are freely set by doctors in private practice, and there is previous evidence from Australia and other countries that prices do matter, and that if prices rise (fall) utilisation falls (rises). This is in addition to the role of other ‘prices’. The first of these is time prices for healthcare – waiting times and travelling times. Waiting times for healthcare can work in a similar way as money prices in other markets. There is significant evidence that waiting times ration demand for healthcare both in the UK and in Australia. Furthermore, time prices also fall when a new health facility (hospital or clinic) is established (or closed), causing utilisation to increase.

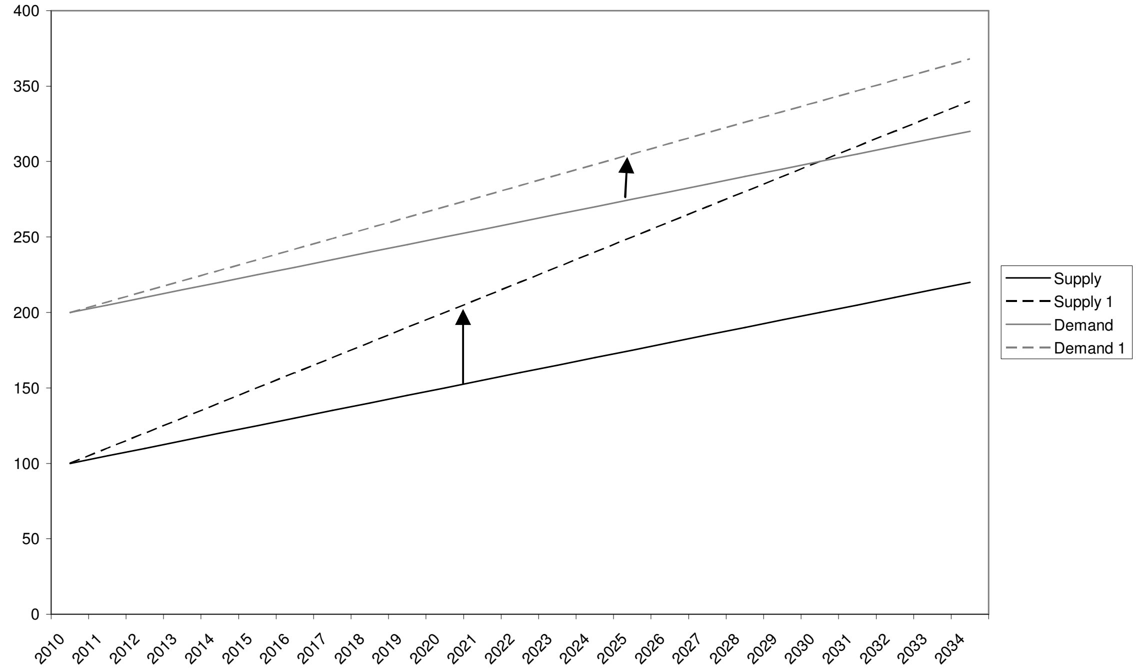
Bias due to model assuming supply and demand independent

A number of biases may appear when supply and demand are diverging or converging. An obvious instance is the ‘balancing’ process which adds graduates to the supply of health professionals until the supply is equal to demand. During the balancing process supply and demand are converging, in the market we would expect prices (time or money) to be falling, increasing utilisation. This would lead to the model predicting too few additional graduates for supply to equal demand, because the model would not predict this extra utilisation caused by lower prices.

An example is in the graph below. The graph plots supply and demand for health professionals over 25 years from 2008 to 2032.

The initial supply and demand for health professionals are indicated by the lines ‘Supply’ and ‘Demand’. There is a 100 unit shortfall between demand and supply (excess demand). Consider the growth of health professionals is boosted, for example by increased number of graduates, and supply moves to ‘Supply 1’. Assuming demand remains the same (at ‘Demand’) supply and demand now balance in the year 2030. However, the change in (money and/or time) prices in the market caused by the increase in supply might imply a rise in demand (here by 20% of the increase in growth of supply) to ‘Demand 1’. The additional growth in supply has lead to extra utilisation (even if health care need has not changed) and so there is still an excess demand in 2032.

Figure 16.



Assumption: health professionals do not directly affect demand (no supplier-induced demand)

Another issue relating to the interaction between supply and demand but outside of basic economic theory is supplier-induced demand. This theory posits that because of the information asymmetry in the healthcare market (Arrow 1963) patients demand depends on the recommendations of their doctors, giving the doctors power to 'induce' unnecessary demand. This is a topic debated extensively in the health economics literature (Fuchs 1978, Grytten and Sorensen 2001, Delattre and Dormont 2003) but it is difficult to test empirically. McRae (2008) finds a small positive effect of GP density on services provided in Australia but can't attribute this to supplier-induced demand or the market mechanism. Peacock and Richardson (2007) found significant supplier induced demand for Australian medical services but the evidence must be regarded as weak, coming from cross-section data.

Bias due to model ignoring supplier induced demand

The bias will be in the same direction as for ignoring the market mechanism – growth of supply will increase demand through lower prices (market mechanism) and through supplier-induced demand, so the NHWT model will predict too few graduates required for supply to meet demand.

5 Conclusions

This research has found that projected workforce requirements from the HWPT tool can be quite sensitive to changes in key assumptions. Changes in exit rates, balancing assumptions, and demand growth, are of particular concern. The uncertainty surrounding the projected workforce requirements should be made explicit in all future reports that use the HWPT. This implies a need for higher quality data in some instances (e.g. for exit rates), and a need for assumptions to be made more explicit and tested more systematically (e.g. assumptions about linear demand and model balancing). The results from the sensitivity analysis should be routinely fed into determining priorities for future improvements in data collection and data quality.