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SCIENTIFIC PAPER

# A 2009 survey of the Australasian clinical medical physics and biomedical engineering workforce

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**Abstract** A survey of the Australasian clinical medical physics and biomedical engineering workforce was carried out in 2009 following on from a similar survey in 2006. 621 positions (equivalent to 575 equivalent full time (EFT) positions) were captured by the survey. Of these 330 EFT were in radiation oncology physics, 45 EFT were in radiology physics, 42 EFT were in nuclear medicine physics, 159 EFT were in biomedical engineering and 29 EFT were attributed to other activities. The survey reviewed the experience profile, the salary levels and the number of vacant positions in the workforce for the different disciplines in each Australian state and in New Zealand. Analysis of the data shows the changes to the workforce over the preceding 3 years and identifies shortfalls in the workforce.

**Keywords** Medical physics · Biomedical engineering · Workforce

## Introduction

In order to ensure that medical physicists and biomedical engineers will be available to meet the medical needs of the future, effective planning in two elements is necessary. Firstly the needs of the future must be evaluated, based on parameters such as population, the incidence of diseases and changes in technology. Secondly, it is important to take note of the current size, level of training and experience, and the age structure of the workforce. With this information, it is possible to estimate the number of new physicists and biomedical engineers required to meet future needs. It is also important to know the salary structures of each jurisdiction so that salary scales can be adjusted to ensure that it is possible to retain the current workforce and attract new recruits.

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## The survey

In the third quarter of 2009 a survey of the medical physics and biomedical engineering work force was carried out in Australia and New Zealand. This followed on from a similar survey carried out in 2006 [1].

To ensure an accurate result, maximum effort was made in ensuring that the majority of the clinical medical physicist and biomedical engineer positions would be accounted for.

The 2006 survey was able to adequately capture, all of the clinical medical physicists in Australasia. Sites that were identified in 2006 as employing clinical medical physicists were again approached for data, along with new private and public facilities that had been established since the last survey.

In regards to improvements in the 2009 survey, more effort was put into identifying all of the professional-level clinical biomedical engineers compared to the 2006 survey, resulting in the identification of more positions, and hence more accurate results.

A survey document was emailed to each of the chief or principal physicists and biomedical engineers requesting the following information for each established position:

- The jurisdiction (i.e. New Zealand or the Australian state or territory) in which they worked.

- The years of relevant experience that the person currently occupying that position had since passing their first degree. If the position was vacant, then the relevant experience they would expect of a person occupying that position was requested.

  Full-time study towards a relevant higher degree would be considered as relevant experience. Experience was recorded in the ranges 0–3, 4–5, 6–10, 11–15, 16–20, and over 20 years experience. It should be noted that those with up to 5 years experience are considered to be 'in training' while those with six or more years experience are considered to be 'qualified'.

- The base salary of the person occupying the position to the nearest $2000 plus any 'top ups' (to the nearest $500) paid to address problems of retention and recruitment. Should the position have been vacant, then an expected salary was asked for.

  Salary data was unavailable for a small number of positions. In some of these cases, especially for the private sector, an indication of how their current salaries related to the relevant public sector award was provided. With this information it was possible to confidently estimate a significant proportion of the undisclosed salaries.

- The fraction of full time spent in each of the disciplines of radiation oncology physics, radiology physics, nuclear medicine physics and biomedical engineering.

  The fraction of time spent on 'other' duties was also recorded, but the stipulation was made that if other duties such as administration were part of the duties required for one of the disciplines, then they should be recorded as part of the fraction in that discipline. Also, in situations where someone was primarily employed in a single discipline but carries out work in another discipline to support the primary discipline, this should be attributed to the primary discipline. For example, a radiation oncology physicist may do a small amount of radiology physics work on the imaging systems in the radiation oncology department where he or she is employed as a fulltime radiation oncology physicist. In such situations the radiology physics time should be attributed to the radiation oncology workforce.

- Whether or not the position was vacant.

After persistent requests, data was obtained from all relevant departments identified. Most of the data was received by mid-September 2009 with the final 4% being obtained by November 2009.

Data was obtained for 623 (495) positions, equating to 575 (478) equivalent full-time (EFT) positions. The unbracketed numbers are for the 2009 survey, the bracketed ones are for the 2006 survey.

Of these positions,

- 75 (62) EFT positions were in New Zealand
- 548 (416) EFT positions were in Australia.

In terms of the individual disciplines

- 330 (268) EFT positions involving 341 (289) individual positions were in radiation oncology physics
- 45 (37) EFT positions involving 67 (67) individual positions were in radiology physics
- 42 (44) EFT positions involving 71 (79) individual positions were in nuclear medicine physics
- 159 (101) EFT positions involving 171 (115) individual positions were in biomedical engineering
- 29 (29) EFT positions were attributed to 'other'.

## The size of the established workforce

The workforce size data for the four disciplines is presented in Table 1. Northern Territory is now included in this survey as positions for professional-level biomedical engineers have been created there and a radiation oncology unit is being established.

It should be noted that the numbers quoted in the table include vacant as well as filled positions. Therefore the table provides data as to the number of established positions, and indirectly (by subtracting the quoted vacancy numbers) the actual workforce size in each jurisdiction.

The data suggests that in the 3 years since the last survey:

- The radiation oncology physics workforce increased by 23%
- The radiology physics workforce increased by 22%
- The nuclear medicine physics workforce decreased by 5%.

The validity of the percentage increases and decreases in the radiology and the nuclear medicine workforces may not be realistic. This is because workforce in these disciplines is very small and it is common for physicists to work in both disciplines and there can be some variance in the fraction of their time attributed to each discipline. However, the 23% increase of the radiation oncology workforce is likely to be quite valid.

In terms of the biomedical engineering workforce, the fact that the 2006 survey did not capture the workforce as well as the 2009 survey means that it is not sensible to estimate a percentage increase for that discipline's workforce.

**Table 1** A breakdown of the medical physics and biomedical engineering workforce in Australia and New Zealand

| | In training | | | Qualified | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0–3 year experience (inc vacancies) | 4–5 years experience (inc vacancies) | 6–10 years experience (inc vacancies) | 11–15 years experience (inc vacancies) | 16–20 years experience (inc vacancies) | More than 20 years experience (inc vacancies) | Vacancies | Total (inc vacancies) | Positions of physicists per million population | Qualified positions physicists per million population |
| Radiation oncology physicists | | | | | | | | | | |
| ACT | 2.0 | 0.0 | 3.0 | 0.3 | 1.0 | 1.0 | 2.0 | 7.3 | 20.8 | 15.1 |
| NSW | 24.0 | 18.0 | 21.3 | 19.0 | 18.5 | 15.9 | 12.0 | 116.7 | 16.4 | 10.5 |
| NT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QLD | 13.0 | 5.0 | 12.0 | 4.0 | 3.0 | 7.4 | 6.0 | 44.4 | 10.1 | 6.0 |
| SA | 10.0 | 4.0 | 6.6 | 5.0 | 0.0 | 0.9 | 3.5 | 26.5 | 16.4 | 7.7 |
| TAS | 0.0 | 1.0 | 1.0 | 0.0 | 1.9 | 2.0 | 0.9 | 5.9 | 11.7 | 9.7 |
| VIC | 6.0 | 5.6 | 15.2 | 11.7 | 7.0 | 10.1 | 4.0 | 55.6 | 10.3 | 8.1 |
| WA | 5.0 | 0.0 | 9.0 | 1.0 | 0.0 | 2.4 | 1.0 | 17.4 | 7.8 | 5.5 |
| Total Australia | 60.0 | 33.6 | 68.1 | 41.0 | 31.4 | 39.7 | 29.4 | 273.8 | 12.5 | 8.2 |
| NZ | 10.0 | 10.0 | 11.3 | 9.6 | 5.2 | 9.0 | 3.4 | 55.1 | 12.8 | 8.1 |
| Radiology physicists | | | | | | | | | | |
| ACT | 0.8 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.8 | 1.1 | 3.1 | 0.9 |
| NSW | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.3 | 1.0 | 3.3 | 0.5 | 0.5 |
| NT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QLD | 1.0 | 2.0 | 4.6 | 1.3 | 1.0 | 1.4 | 0.0 | 11.3 | 2.6 | 1.9 |
| SA | 0.8 | 0.0 | 0.3 | 0.0 | 0.8 | 0.7 | 1.5 | 2.6 | 1.6 | 1.1 |
| TAS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VIC | 2.6 | 1.0 | 0.8 | 0.6 | 0.0 | 1.8 | 0.0 | 6.8 | 1.3 | 0.6 |
| WA | 3.5 | 2.0 | 3.0 | 2.7 | 0.0 | 0.4 | 1.0 | 11.6 | 5.2 | 2.7 |
| Total Australia | 8.7 | 5.0 | 9.7 | 5.9 | 1.8 | 5.6 | 4.3 | 36.7 | 1.7 | 1.1 |
| NZ | 0.0 | 1.0 | 1.9 | 0.3 | 1.3 | 2.3 | 0.3 | 6.8 | 1.6 | 1.3 |
| Nuclear medicine physicists | | | | | | | | | | |
| ACT | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.3 | 0.6 | 1.7 | 0.9 |
| NSW | 3.0 | 2.9 | 5.0 | 4.0 | 1.4 | 5.1 | 0.0 | 21.4 | 3.0 | 2.2 |
| NT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QLD | 0.0 | 1.0 | 1.4 | 0.2 | 2.0 | 1.0 | 1.0 | 5.6 | 1.3 | 1.0 |
| SA | 0.8 | 1.0 | 0.2 | 0.0 | 0.3 | 3.0 | 0.8 | 5.3 | 3.3 | 2.2 |
| TAS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VIC | 0.4 | 0.0 | 0.1 | 0.2 | 0.0 | 2.0 | 0.0 | 2.7 | 0.5 | 0.4 |
| WA | 1.1 | 0.0 | 0.6 | 1.9 | 0.0 | 0.1 | 0.0 | 3.7 | 1.7 | 1.2 |
| Total Australia | 5.6 | 4.9 | 7.3 | 6.6 | 3.7 | 11.2 | 2.1 | 39.3 | 1.8 | 1.3 |
| NZ | 0.0 | 1.0 | 0.3 | 0.0 | 1.2 | 0.1 | 0.0 | 2.6 | 0.6 | 0.4 |

**Table 1** continued

| | In training | | Qualified | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0–3 year experience (inc vacancies) | 4–5 years experience (inc vacancies) | 6–10 years experience (inc vacancies) | 11–15 years experience (inc vacancies) | 16–20 years experience (inc vacancies) | More than 20 years experience (inc vacancies) | Vacancies | Total (inc vacancies) | Positions of engineers per million population | Qualified positions engineers per million population |
| Biomedical engineers | | | | | | | | | | |
| ACT | 0.0 | 0.0 | 0.5 | 0.9 | 0.0 | 0.0 | 0.0 | 1.4 | 4.0 | 4.0 |
| NSW | 2.0 | 2.0 | 2.0 | 2.0 | 4.0 | 7.0 | 0.0 | 19.0 | 2.7 | 2.1 |
| NT | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.0 | 2.0 | 8.9 | 4.4 |
| QLD | 7.0 | 0.0 | 3.2 | 0.0 | 2.0 | 2.2 | 0.0 | 14.4 | 3.3 | 1.7 |
| SA | 8.2 | 2.0 | 5.8 | 2.0 | 1.0 | 3.4 | 0.0 | 22.4 | 13.8 | 7.5 |
| TAS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VIC | 9.0 | 11.0 | 15.0 | 14.6 | 10.5 | 10.5 | 2.0 | 70.6 | 13.1 | 9.4 |
| WA | 4.0 | 3.0 | 5.0 | 2.0 | 3.0 | 8.0 | 3.0 | 25.0 | 11.2 | 8.0 |
| Total Australia | 30.2 | 18.0 | 31.5 | 22.5 | 20.5 | 31.1 | 6.0 | 153.8 | 7.0 | 4.8 |
| NZ | 0.0 | 0.0 | 2.0 | 0.2 | 1.3 | 1.3 | 0.8 | 4.8 | 1.1 | 1.1 |

All numbers are in EFTs

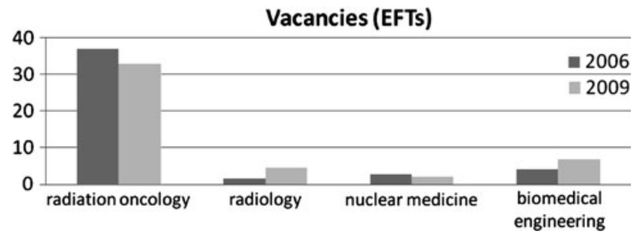


**Fig. 1** Vacancies in the workforce in 2006 and 2009

The number of vacancies in each discipline in 2006 and 2009 are shown in Fig. 1.

It is noted that the number of vacancies has not changed significantly. There is a small reduction in the number of radiation oncology physicist vacancies, while in the other disciplines the number of vacancies is so small that any change is probably not if any real significance.

However, as the radiation oncology workforce has increased by 23%, then the vacancy rate in that discipline has probably decreased by 25% over the intervening 3 years.

## Radiation oncology physicist positions

The numbers of radiation oncology physicists employed in each jurisdiction in 2006 and 2009 are shown in Fig. 2. There has generally been an increase in the workforce in each jurisdiction although the workforces in Tasmania and Western Australia have been relatively static.

The experience level of the combined Australian and New Zealand radiation oncology physics workforce is shown in Fig. 3. It is apparent the size of the workforce at the junior levels is increasing at a faster rate than the senior levels. This is likely to be due to the establishment of the Australasian College of Physical Scientists and Engineers in Medicine's Training, Education and Accreditation Program (TEAP), and concerted recruitment efforts into that program.

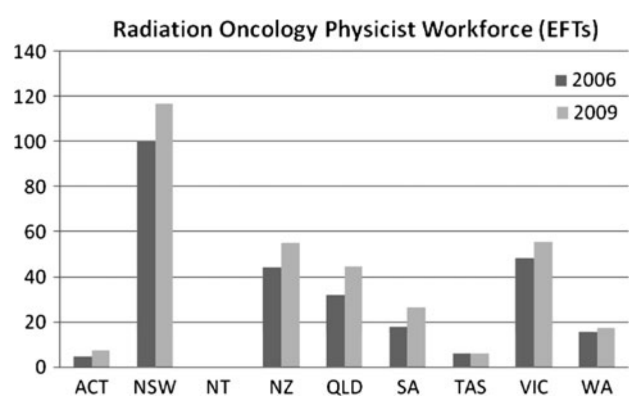


**Fig. 2** The radiation oncology physicist workforce in the jurisdictions

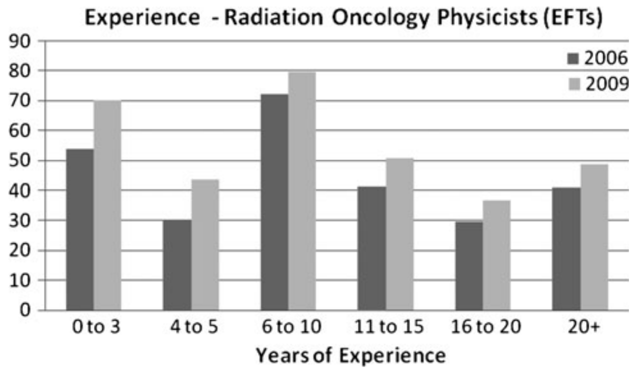


**Fig. 3** The experience level of the Australian and New Zealand radiation oncology physicist workforce

At the time of the survey, there were approximately 141 linear accelerators in use in Australia, and 25 in New Zealand. This is a 25% increase over 3 years in the number of linear accelerators. At the same time, the workforce has expanded by 23%. Therefore while the workforce is expanding to meet the increased number of linear accelerators, it is not yet overcoming the workforce shortage.

Using a figure of 1.7 qualified radiation oncology physicists per linear accelerator (now a widely accepted guideline), there would need to be 240 and 43 medical physicists who are clinically qualified in radiation oncology physics in Australia and New Zealand respectively. In fact, there were only 180 EFT qualified positions in Australia and 35 in New Zealand and after accounting for vacancies, there are only 157 EFT in Australia and 33 EFT in New Zealand. This represents a shortfall of 35 and 23% in qualified staff as opposed to shortfall of 32 and 15% respectively in 2006.

Care must also be used in applying 1.7 qualified physicists per linear accelerator. This is a simplification of the more complicated ACPSEM Formula 2000 [2] that must be used when assessing the physicist needs of an individual department. The simpler formula can only be used when averaging over a large number of departments such as on a national or jurisdiction-wide basis and not applied to individual hospitals where the need may be higher. For example, if specialized techniques such as brachytherapy or radiosurgery are practiced in a small department, then the simple formula will grossly underestimate the staffing requirements. Further, with the introduction of more technical and physics-intensive techniques such as IGRT, Formula 2000 must be reassessed to take into account the increased physics input.

It is also generally accepted that there should be 0.5 trainee radiation oncology physicists per linear accelerator. In a steady state situation, where there is no shortage in the radiation oncology physicist workforce, and the number of linear accelerators is the same as current levels, there should be 71 radiation oncology physicists in training in Australia and 13 in New Zealand. The survey has identified 93.6 EFT positions for radiation oncology physicists with less than 5 years experience in Australia and 20 EFT positions in New Zealand. However not all were filled and there were, in fact 87.6 EFT and 19 EFT positions in Australia and New Zealand respectively. This suggests that there are currently more trainee positions available than are required. However a steady state situation does not exist and while there is a shortage in the qualified physicist workforce that needs to be overcome, the number of trainee physicists needs to be considerably higher than 0.5 trainee radiation oncology physicists per linear accelerator, to ensure that the required number of qualified physicists is eventually met. In addition, increasing referral rates and the increasing number of accelerators being installed increases the need for qualified radiation oncology physicists, which increases the need for trainees. In a situation where there is an international shortage, the number of trainees must be higher yet, to overcome the tendency for qualified physicists to move overseas to higher paid positions with better working conditions, more advanced technology, and better research opportunities.

Of special note is the wide variation in the number of radiation oncology physicist positions per million population from jurisdiction to jurisdiction. The variation of nearly 3:1 over the jurisdictions is surprising and indicates acute shortages in some jurisdictions.

## Radiology physicist positions

The changes in the radiology physicist workforce in each jurisdiction are illustrated by Fig. 4. While the workforce showed an overall increase over the 3 years since the previous survey, the changes in the jurisdictions vary greatly with some showing marked increases and others showing marked decreases. However, as highlighted earlier, it is not unusual for a physicist to work in nuclear

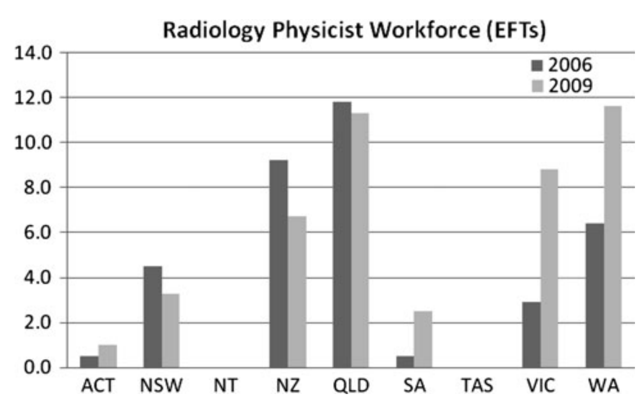


**Fig. 4** The radiology physicist workforce in the jurisdictions

medicine as well as radiology, and the assessment of the amount of time spent in each discipline may have changed in actuality or perception.

Again, the number of physicist positions per million of population varies considerably from jurisdiction to jurisdiction, but in this case by a factor of 10:1, as it did in the 2006 survey. In jurisdictions where the need for physicist supervision of imaging equipment is well recognized and established, the relative number of physicists is more appropriate, but clearly some jurisdictions are underserviced.

The experience level of the workforce does seem to have changed over the preceding 3 years. This is demonstrated by Fig. 5. There has been a considerable increase in the number of physicists with 6–10 years experience. Also, there has been a decrease in the number of physicists with over 10 years of experience. This is a point of concern as it means that those with the most experience are exiting the workforce.

The opportunities to train further radiology physicists are, however, more limited than those for training radiation oncology physicists. This is because many radiology physicists do not work entirely within the discipline, and they often have minimal support from other radiologists in their place of employment. A different training strategy from the TEAP for the radiation oncology physicists must be developed for radiology physicists.

## Nuclear medicine physicist positions

Changes to the nuclear medicine physicist workforce in each jurisdiction are illustrated by Fig. 6.

Overall there has been a small reduction in the workforce, although this is most noticeable in the same states where there has been an increase in the radiology physicist workforce (Western Australia and Victoria). Possibly this is just a reflection of the imaging physicists have reallocating their time between nuclear medicine and radiology.

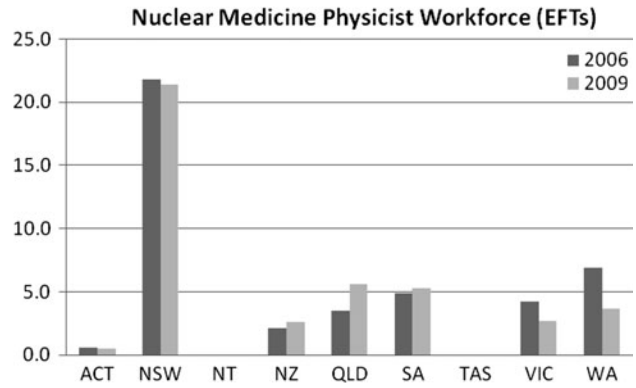


**Fig. 6** The nuclear physicist workforce in the jurisdictions

The experience level of the combined Australian and New Zealand nuclear medicine physicist workforce and the way it has changed since 2006 is shown in Fig. 7.

The disturbing feature of the workforce is the very high proportion of the workforce with more than 20 years experience. This indicates a bias towards older physicists being involved in the discipline, and indicates that there is an urgent need to train more young physicists. The lack of physicists with less than 10 years experience in some jurisdictions clearly demonstrates that there has been no consideration given to training the next generation of nuclear medicine physicists.

The number of nuclear medicine physicist positions per million population varied from jurisdiction to jurisdiction by a factor of 6:1, indicating that some jurisdictions have a severe shortage of nuclear medicine physics expertise.

## An international comparison of the medical physics workforces

Detailed studies of the medical physics workforce are few, and it is valuable to compare the Australasian situation to that of countries of a similar socioeconomic status.

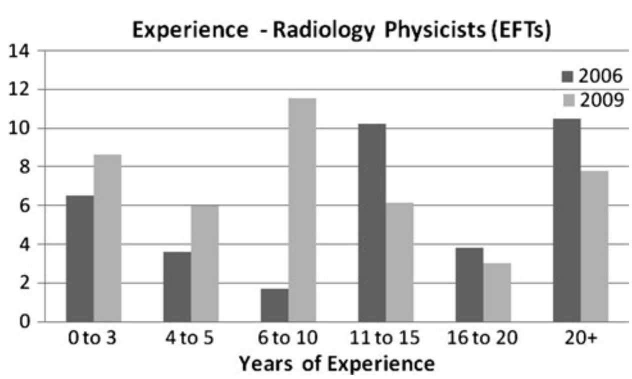


**Fig. 5** The experience level of the Australian and New Zealand radiology physicist workforce

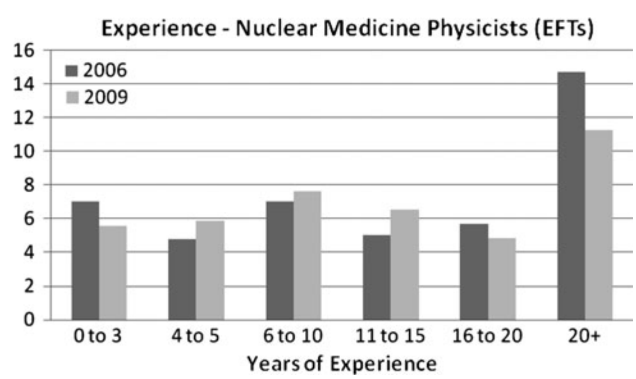


**Fig. 7** The experience level of the Australian and New Zealand nuclear medicine physicist workforce

In 2002 the German Society for Medical Physics published a workforce analysis that details the actual size and the expected size of the workforce [3]. The length of training post secondary school to become a qualified medical physicist in Germany is similar to that required in Australasia (~8 years) [4]. The study categorizes physicists into those involved in radiation oncology physics, radiology physics, nuclear medicine physics and radiation protection; while the survey reported here distributed the radiation protection aspect of physicists' duties into the other three categories directly. By taking the data from the German survey and distributing the radiation protection workforce through the other three categories in proportion to the size of the reported workforce in those categories, a sensible comparison is able to be made between the Australasian and the German workforces. The comparison is given in Table 2. It should be noted that the staffing levels recommended in Germany are population based, and while the population is generally aging and thus medical needs are increasing, the German recommendations are likely to be low numbers.

The workforce numbers in the table for Australia and New Zealand include vacant positions, therefore they do not represent the true workforce. The German survey was not so robust in capturing the entire medical physics workforce as in the survey reported here, so the actual workforce size is not reported. However the German report indicated that there was a substantial deficit in the workforce in all disciplines.

The recommended radiation oncology workforces for Australia and New Zealand were calculated on the basis of 1.7 qualified radiation oncology physicists per linear accelerator, the actual number of linear accelerators and the population. It is seen that the recommended per capita sizes of the qualified radiation oncology physicist workforces in Australia and New Zealand are similar to the recommended size for Germany, although in all three countries the actual number of positions is less than that.

Recommended levels for the nuclear medicine and radiology physics workforces in Australia and New Zealand have not yet been developed. However, it is seen from the table that the workforce numbers in these disciples in Australia and New Zealand are substantially lower than those recommended in Germany. Clearly the Australian and New Zealand nuclear medicine and radiology physics workforces must be urgently increased.

## Biomedical engineering positions

The size of the professional-level biomedical engineer workforce is seen in Fig. 8. As the 2006 survey was not as robust when accounting for the biomedical engineer workforce, comparing the 2006 and 2009 workforces is not sensible. The number of engineers per million of population reported in Table 1 varies considerably from jurisdiction to jurisdiction.

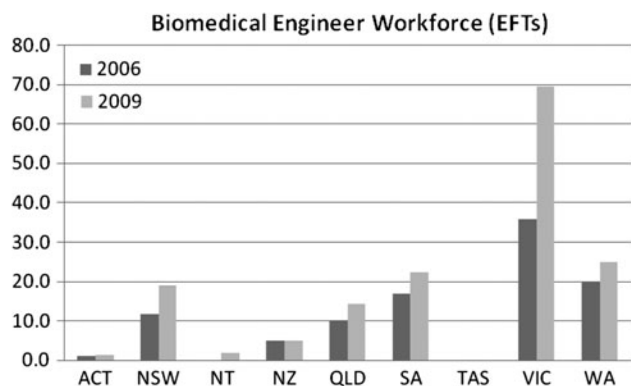


**Fig. 8** The biomedical engineer workforce in the jurisdictions

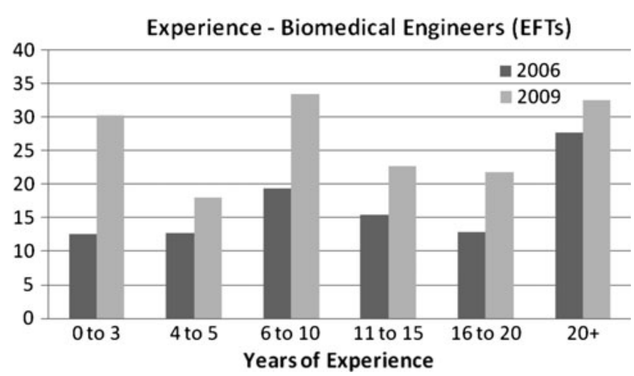


**Fig. 9** The experience level of the Australian and New Zealand nuclear medicine physicist workforce

**Table 2** Recommended and actual sizes of the medical workforce in Germany, Australia and New Zealand

| Qualified physicists per million population | | | | | |
|---|---|---|---|---|---|
| | Germany Recommended | Australia Actual | Australia Recommended | New Zealand Actual | New Zealand Recommended |
| Radiation oncology | 8.5 | 8.2 | 9.2 | 8.1 | 8.1 |
| Radiology | 6.4 | 1.1 | | 1.3 | |
| Nuclear Medicine | 3.2 | 1.3 | | 0.4 | |

The experience level of the combined Australian and New Zealand biomedical engineer workforce is shown in Fig. 9. Again the 2006 data should be treated with caution. Figure 9 indicates a good experience profile with respect to age for a growing workforce.

## Salaries

The salary data analyzed here is that of medical physicists and biomedical engineers actually employed. It also includes data for vacant positions for which a sensible estimate of the applicable salary can be made. It also includes supplements that are paid to ensure staff retention, except for the radiation oncology physicists in Tasmania who receive a supplementary payment so that their salaries are similar to those paid at Barwon in Victoria. The data is weighted according to the EFT of each position.

## Radiation oncology physicists

Figure 10 shows the average salaries in each jurisdiction. The average salary varies from jurisdiction to jurisdiction at each level of experience and, although this is not shown, can vary considerably within each jurisdiction. New South Wales stands out as the jurisdiction that most appropriately rewards its physicists for their expertise especially at the more senior levels. Generally the salary levels in Tasmania, Western Australia, New Zealand and Victoria are lower than those in New South Wales, Queensland and South Australia.

Radiology physicists

Figure 11 shows the average salaries for radiology physicists in the different jurisdictions. Tasmania is not represented in this figure as there are no clinical radiology physicist positions in that state.

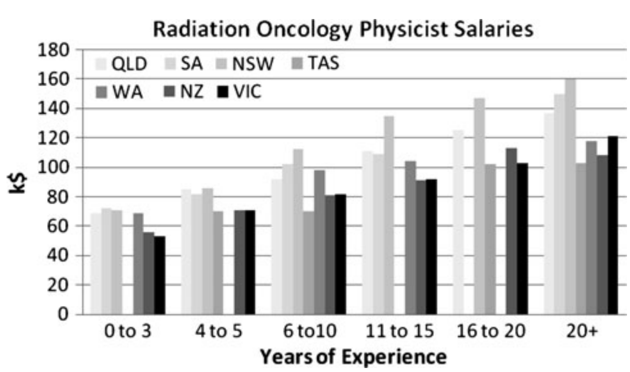


**Fig. 10** The average salaries of radiation oncology physicists in different jurisdictions for different levels of experience

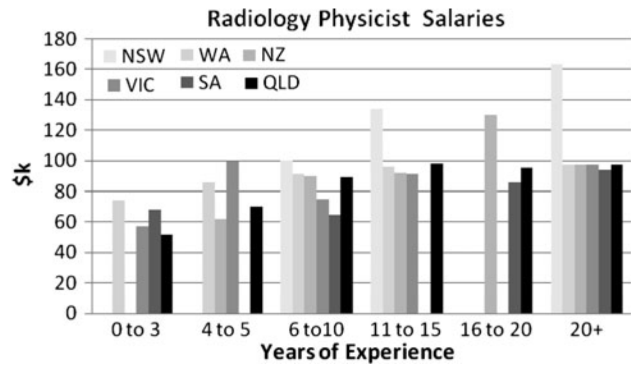


**Fig. 11** The average salaries of radiology physicists in different jurisdictions for different levels of experience

Generally, the data represented by the figure is rather noisy as there are not many radiology physicists employed in Australasia. However, New South Wales stands out as the jurisdiction that offers the best salaries.

## Nuclear medicine physicists

Figure 12 shows the average salaries for radiology physicists in the different jurisdictions. Again, Tasmania is not represented in this figure as there are no clinical radiology physicist positions in that state.

As for the radiology physicists, the data represented by the figure is rather noisy as there are not many nuclear physicists employed in Australasia. However, New South Wales again stands out as the jurisdiction that offers the best salaries.

## Biomedical engineers

Figure 13 shows the average salaries of biomedical engineers in the different jurisdictions. There is a large variation in the salary levels for each level of experience

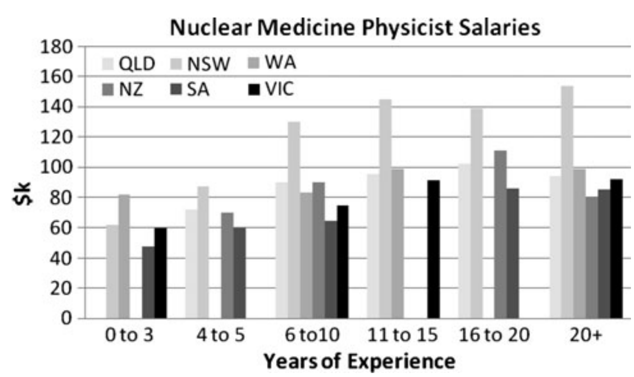


**Fig. 12** The average salaries of nuclear medicine physicists in Australia and New Zealand for different levels of experience

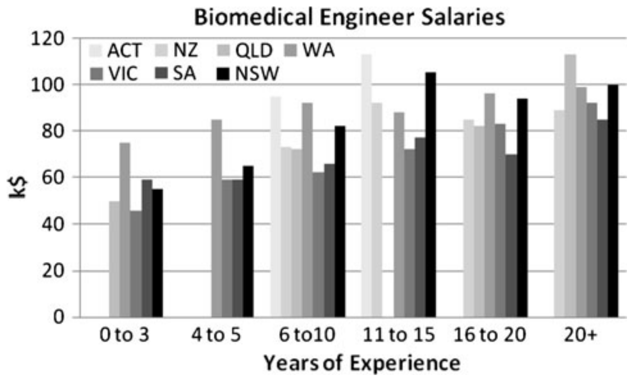


**Fig. 13** The average salaries of biomedical engineers in different jurisdictions for different levels of experience

although the variation tends to lessen at the more senior levels. There seems to be no jurisdiction that consistently offers higher or lower salaries than the rest.

## Discussion

The survey provides the opportunity to evaluate the changes in the medical physics and biomedical engineering workforce from 2006 until 2009.

### Radiation oncology physics

The relatively large number of radiation oncology physicists makes it possible to make a reliable analysis of this part of the workforce.

It is encouraging that between 2006 and 2009 the vacancy rate for radiation oncology medical physicists has dropped from 13.8 to 10.7% in Australia and 13.7 to 6.2% in New Zealand. At the same time number of physicist positions per million of population has increased by 17% in Australia and 23% in New Zealand.

It should be noted that the number of qualified positions per million of population over this period has increased by 14% in Australia and 4% in New Zealand. This indicates that while the experience profile of the Australian workforce has not changed dramatically, other than that the slight increase from 33 to 34% in the fraction of unqualified physicists, the profile in New Zealand has changed with the fraction of unqualified physicists increasing from 24 to 36%.

### Radiology physics

While the number of qualified physicists per million head of population in Australia and New Zealand in radiation oncology is close to the German guideline, the numbers of radiology physicists is considerably lower and this is a matter of major concern. To meet the German guideline, Australia would need to employ 140 qualified radiology physicists and New Zealand would need to employ 28. Currently there are 23 positions in Australia and 5.8 in New Zealand. It is difficult to imagine how this situation can be remedied in the short term. This will require significant government funding and a commitment by the jurisdictions to establish the physicist positions. There are significant logistic problems in establishing training in some jurisdictions as there is little or no capacity to train further physicists.

### Nuclear medicine physics

The numbers of both nuclear medicine physicist and radiology physicist positions vary considerably from jurisdiction to jurisdiction. There is a demonstrable lack of nuclear medicine physicist positions in all jurisdictions. To reach the German standard there should be approximately 70 EFT qualified nuclear medicine physicist positions in Australia and 14 in New Zealand, whereas currently there are 29 and 2.6 EFT qualified nuclear medicine physicist positions respectively in those countries. With the increasing use of PET scanning, which requires more significant physicist input than other nuclear medicine techniques, the need for nuclear medicine physicist positions is certainly going to be greater than 70 and 14.

To meet the need to train nuclear medicine physicists for the future, it is vital that the TEAP in nuclear medicine physics is also developed to the same extent as the TEAP in radiation oncology physics. Again, this will require significant government funding and a commitment by the jurisdictions to establish the physicist positions.

### Biomedical engineering

As greater care was taken in accounting for all of the professional-level clinical biomedical engineers for the 2009 survey, the data is more robust than that of the 2006 survey. The numbers of biomedical engineers per million of population varies considerably. While Victoria has a high proportion of engineers and benefits from the expertise that they can contribute, Tasmania has none and relies only on technician engineers. It should be noted that Northern Territory is now establishing professional biomedical engineering positions and they appear in this survey for the first time.

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