

A Cost-Benefit Comparison of Surgery and Radiation Therapy for the Treatment of Common Cancers in Australia

Report to the Radiation Therapy Advisory Group

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Executive Summary

This paper is a cost-benefit analysis of surgery and radiation therapy for five tumour streams, viz.: breast; prostate; lung; cervix; and head and neck cancers. We construct a series of models to consider whether funding is currently efficiently allocated to different modes of cancer treatment.

The import of this study is that both limited supply of alternative treatments, and competing financial incentives may in both the short and longer terms skew clinical pathways, and affect the optimal utilisation of critical cancer treatment services.

The issue of supply is fundamental. A recent study shows that 14.2% of patients who would benefit from radiation therapy miss out on this service. Combining this shortage with our cost-benefit analysis, we conclude that as well as being inequitable, this is in many cases also economically inefficient.

We have isolated the *social* price of treatment for surgical intervention, which is either a National Weighted Activity Unit in the public sector, or a combination of aggregate MBS scheduled fees plus partially-subsidised health insurance payments in the private sector. For outpatient radiation oncology services, this is almost universally the MBS price. We note that we have provided two pricing streams for radiation oncology, separating 3D-CRT pricing from emerging IMRT/IGRT prices.

A key element of our model is the exclusion of out-of-pocket costs, as these are taken from consumer surplus. We also exclude capital expenditure and pre-treatment diagnostic costs. We find that out-of-pocket costs are likely to be substantially higher in the case of private sector surgery than for equivalent radiation therapy. The implications of this are discussed below.

The exclusion of OOP costs is consistent with our overall approach to be as conservative as possible. We have looked at high costs for radiation oncology with IMRT, while only comparing mean costs of surgery. This is to maximise the robustness of our model and conclusions.

We look at multiple cases to compare costs of surgery and radiotherapy. Our primary model is to compare the ratio of incremental gains from competing or combined therapies, with the incremental costs of the same. Where the ratio of gains exceeds the ratio of costs, the treatment is more efficient. Our target event is avoidance of any recurrence of the primary cancer.

A full schedule of outputs is found at Appendix A. Where the cost-benefit ratio exceeds 1, radiation therapy is an efficient substitute for, and addition to surgery. These cases each argue for greater access to radiation therapy.

In the case of breast disease, where radiation therapy is an adjuvant therapy, most of the benefit in terms of avoided recurrence is captured by surgery. Consequently, we find that surgery is the more efficient contributor to desired outcomes, but that there is still cost-efficiency for the addition of radiation.

The latter is demonstrated by a second model, looking at willingness to pay: comparing the gain from adjuvant radiation therapy (in breast cancer) and salvage radiation therapy (in prostate cancer), against a quality-adjusted life-year value of \$50,000.



In all cases, the cost of radiation therapy is substantially less than the financial value of life time gained.

Looking back to the issue of out-of-pocket costs, we conclude that the apparent cost-benefit (comparative efficiency) of radiation oncology is significantly affected by current public policy with respect to compensation. This is obvious where there is a cost-benefit of lower than 1, caused only because surgery is notionally substantially cheaper in the private than in the public sector.

To illustrate this issue, we have also calculated the cost-benefit of prostate surgery including a range of reported out-of-pocket costs. This shows the cost-benefit in real prices faced by consumers, and underlines the effect of cost-shifting.

Whereas the MBS has kept pace with the higher costs of emerging radiation technologies, it appears to rely on substantial cost shifting to the private purse (the consumer) for a number of surgeries. We see this in reports of high out-of-pocket costs for surgery, which do not occur in radiation therapy for the same cancers. Potentially, it is also the case that information asymmetry and cultural expectations combine to make surgery an unnecessary first choice for many people, which will in turn increase demand against finite supply, and present the appropriate conditions for high out-of-pocket costs.

This is not equitable, and we have observed the migration of surgical activity from the public to the private sector for selected cancers, even though the nominal *social* price is much higher in the public sector. This in turn appears to contribute to suboptimal allocation of treatment for examined tumour streams, due to prevailing financial incentives, and lower rates of referral to multidisciplinary teams. There is a capacity in surgery to raise prices due to lack of consumer knowledge of alternatives, as well as scarce supply of services. This is rational market behavior.

Compounding this, there is strong evidence that suboptimal utilization of radiation therapy is due to a simple lack of resources, in both urban and regional settings across Australia. Given that there are clear cost benefits for patients in a number of the cancers we examined, this presents limits to access to the most efficient treatment, where it is clinically indicated. There are also equity and welfare losses here.

It would be of particular concern if the lower cost of surgery to the MBS in the private sector were to hold back willingness to fund new radiation oncology services.

There is a range of policy and fiscal issues to be considered here. Our model is sensitive to changes in all settings, so alternative policy options can easily be informed.

Finally, we note two issues of caution. First, none of these data should be used to argue for lower payments for surgery. Our conclusion is that there should be more radiation therapy used where clinically suitable, and that there may be some under-compensation for radiation oncology, particularly in private markets where there is limited consumer surplus.

Second, none of this economic analysis is itself an argument for change in clinical practice. Our cost-benefit ratios are derived from published hazard ratios which are the proper basis of clinical selection, combined with individual patient characteristics.



Project Design and Data Treatment

Introduction: Allocative Efficiency in Cancer Services

This study applies a form of cost-benefit analysis to the treatment of common cancers in Australia, focusing on five tumour streams, viz.:

- Breast;
- Prostate;
- Lung;
- Cervix; and,
- Head and Neck (oropharyngeal);

The primary purpose of this exercise is to identify whether the baseline funding (either public or privately insured or both) for different components of cancer care reflects the relative contribution of each component to desired outcomes. This is in the broad sense a question of efficacy: if there is a disparity between pricing and outcome, this is likely to be reflected in a suboptimal allocation of services.

Sub-optimal allocation may have a range of consequences, including:

- Lower valuation of services in the health system, leading to less investment in infrastructure and personnel, particularly in public hospitals;
- Similar effects in the private sector, leading to underinvestment in both infrastructure and employment;
- Compounding effects through unwillingness of capital markets to lend against practices with lower observed return on investment;
- Skewed career paths, with medical graduates selecting either more lucrative specialisations, or roles with greater security, due to higher investment;
- Consequent misallocation of services, due to the professional and cultural anchors which prevail in different siloes of the medical profession; and,
- Suboptimal care in some cases, where selection of treatment reflects professional bias or economic incentives.

All of these are medium- to long-term effects, and difficult to measure. Nonetheless, we know as a starting point that there is an observed gap between optimal cancer treatment and current practice in Australia.



An example of this is the recent assessment that 14.2% of cancer patients in Australia who would benefit from radiation therapy, miss out on this service¹. Some of this may be due to regional maldistribution of infrastructure, and some may be due to variance in clinical decision-making. However, each of these may be expected to respond to price signals over time.

In practical terms, lack of access to radiation therapy may lead to unnecessary mortality. A recent study showed that 85 deaths from breast disease might have been avoided in NSW over a three-year period with optimal rates of radiotherapy use.²

The five cancers we have selected are due to their receptivity to multiple treatment modes, as well as their general prevalence, but also to reflect observed disparate treatment pathways. While there are variations in practice due to presentation of the diseases, the modal approach to these cancers is:

- In the case of breast disease: always surgery plus maybe adjuvant radiation therapy;
- In the case of other tumour streams: either surgery or primary radiation therapy.

In each of these cases the options also include: chemotherapy supervised by a medical oncologist (physician); or may be to undertake no immediate intervention and simply observe the cancer. At the same time, each individual case will have unique features which affect clinical decisions. We note that the approach and methodology of this paper does not address the treatment of individual cases: it purely looks at the economics of treatment decisions on a national basis.

Why does suboptimal allocation occur?

The suboptimal allocation of all medical services may be caused by a range of factors. Broadly speaking, these can be described in three sets³:

- Inadequate infrastructure footprint. This may be a lack of necessary service volume in an urban setting, or a lack of any proximate radiation oncology facilities in even some relative dense areas of regional Australia. As an example, it is estimated that despite rapid rollout of new Linacs across Eastern Australia in recent years, we are still well below optimal use of radiation therapy for cancer, simply because we have not yet reached the threshold where demand and supply might intersect⁴;
- Demographic effects. A key issue here is remoteness and regionality. We know that for any given condition, people in remote Australia are more likely to be hospitalised, as they have less access to outpatient or subacute options. This may bias treatment toward surgery; and,

¹ Royal Australian & New Zealand College of Radiologists, Planning for the Best: Tripartite National Strategic Plan for Radiation Oncology, 2012-2022 (Sydney: 20 June 2012), p.31

² Merie, R et al, "Comparing Evidence-based recommendations for radiotherapy use against routine practice in breast cancer", (2018), presentation supplied

³ Notably these overlap with consequences above, suggesting recursive causes and consequences

⁴ See, for example, Barton, MB and Delaney, GP, "A decade of investment in radiotherapy in New South Wales: why does the gap between optimal and actual persist", *Journal of Medical Imaging Radiation Oncology*, (August 2011: 55:4) 433-41



- Culture. There is a likely intersection here between professional tendency, economic incentives, and information asymmetry (patients do not know their options).⁵ For example, a key difference between breast and prostate cancer treatment has been the normalisation of multidisciplinary teams in the former, as opposed to primary management by a urologist in the latter.

On the third point, we note forthcoming research which shows comparative referral rates to multidisciplinary teams, across different cancer sites. The data from this are: lung 100%, upper gastrointestinal 100%; colorectal 85%; breast 75%; malignant haematology 65%; and genitourinary 35% (prostate 29%, bladder 54%).

Notably Prostate cancers represent 74% of all genitourinary cancers⁶, so the difference in referral practice between urologists focusing on prostates and those on bladders is important and informative.

One possible driver of this, identified as part of our consultation, is that public hospitals have formal multidisciplinary groups, which is not a universal characteristic of private hospitals. Consequently, cancers which are predominantly treated in a public setting – such as lung disease – will be expected to have a higher referral rate. Nonetheless, this does not explain the disparity between – for example – breast and prostate referral rates.

The problem, as anticipated above, is that infrastructure investment – particularly in regional areas – and cultural change in medical activity are very slow to change. This is compounded by financial incentives to prefer surgery for some cancers. These incentives are amplified by the prospect of high out-of-pocket costs for some surgeries.

Out-of-Pocket Costs

We are aware that there has been substantial media and political attention paid to out-of-pocket (OOP) costs for cancer treatment in Australia. This is currently being reviewed by a Ministerial Advisory Committee focusing on transparency of healthcare costs.⁷

This is a significant issue in relation to access to cancer treatment, because treatment is rationed in two intersecting ways:

1. Government-funded public care is rationed through waiting lists, which both prioritise diagnosis-related groups (DRGs) and at the same time prioritise patients within DRGs; and,
2. The market for supply of treatment services – both at the current time, and in the future due to control of training programs – is predominantly controlled by a finite number of medical specialists.

⁵ See for example, <http://mobile/abc.net.au/news/2016-05-25/claims-prostate-cancer-patients-not-given-choice-about-treatment/6495206>

⁶ Atwell, Daisy et al, “Referral rates to multidisciplinary team meetings: is there disparity between tumour streams?”, forthcoming publication in *Journal of Medical Imaging and Radiation Oncology*, version supplied by authors

⁷ <http://www.health.gov.au/internet/main/publishing.nsf/Content/out-of-pocket-costs-tor> Downloaded 6 August 2018

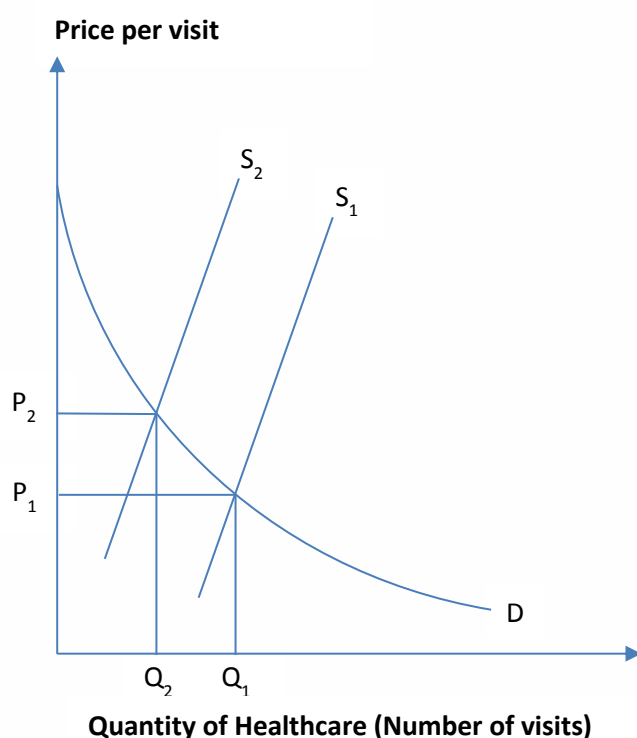


The consequence of this is that medical specialists are able – in the private sector – to ration supply of scarce services according to consumer willingness to pay. This is a form of market segmentation, combined with an auction element.

At the same time, the existence of parallel public and private markets provides an incentive for specialists to increase their supply in the market which permits the greatest profit: with few exceptions, this will be the private market.

The following diagram illustrates the issue of OOP costs:

Figure 1: Price & Supply in Healthcare⁸



This diagram is for illustrative purposes only and does not reflect any specific data. Nonetheless, the chart illustrates some expected features of the Australian public healthcare market, including:

- A demand curve **D**, which shows that demand will increase for healthcare services as the consumer price falls. The gradient of this curve will depend upon the necessity and urgency of health interventions. The curve is asymptotic toward the axes because some the rate of demand slows at a diminishing rate for wealthier consumers⁹;

⁸ For discussion of a similar chart, see Griffin, Charles C, "Welfare gains from user charges for government health services", *Health Policy and Planning* (Oxford: Oxford University Press, 7(2), 1992), p.177

⁹ This is similar to a Lorenz curve, so gradient will broadly reflect a market's Gini coefficient



- If we increase public subsidy from S_1 to S_2 , and the healthcare budget remains finite, then the quantity of public services supplied must decrease accordingly. This will be a welfare loss despite the higher subsidy;
- Consumer surplus (willingness to pay an incremental price) for healthcare services is given by the area under D and respectively above the prices P_1 and P_2 , depending upon the Government subsidy.

The consequence of this model is that the Government simultaneously risks over-subsidising some consumers' healthcare, while reducing the welfare of others by extending waiting lists.

In practice, Australian governments address this matter in multiple ways. The most obvious of these lies in forms of means testing: wealthier consumers are incentivised via the tax system to take out private health insurance (PHI), and the Government pays a decreasing subsidy according to their income; poorer consumers may receive higher subsidies for necessary medicines.

However, this issue is also dealt with through a deregulated price market, permitting individuals and groups of specialists to set their own market-clearing prices in the private healthcare market. We say there are multiple market-clearing prices because there is no single national healthcare market, and there appear to be micro-markets within even quite small areas of our capital cities, or within particular demographics (e.g. ESL markets).

What is occurring here in economic terms is that medical specialists are maximising their incomes by seeking to capture the largest possible proportion of available consumer surplus. This meets general expectations that scarce supply of services will find result in some measure of rents.

This may be compounded by cultural expectations intersecting with information asymmetry, because people are conditioned to expect surgery as a first choice for cancer treatment. At the same time, there may be a bias caused by the structure of private health insurance, which contributes to inpatient surgical services, but not to outpatient radiotherapy (though this is mostly for the hospital costs).

One hypothesis may be that cost-shifting is more acceptable in in-patient services where there is a choice between public and private services. By comparison, outpatient services such as GPs and radiation oncology may be more sensitive in the public mind to OOP costs.

Notwithstanding that this is normal economic behavior, there are several issues of concern here. The first – as noted in our introduction – is that greater capacity to capture consumer surplus skews the supply of healthcare against optimal distribution.

This in turn may draw resources from public into private markets. An apparent example of this is prostate surgery: in the most recently available statistical data, more than twice as many prostatectomies were



performed in private hospitals compared to public.¹⁰ We accept that there may be multiple factors driving this, not least that the median waiting time for prostatectomy in public hospital is over 40 days.¹¹

Nonetheless, demand in the private sector combined with high information asymmetry between patients and consulting urologists has the potential for a vicious cycle of increasing OOP costs.¹² This is an exceptionally difficult problem to address, given parallel markets and scarce supply of services.

The greater concern here is that the available returns on surgical intervention will distort clinical choices.

Having considered all of these issues – and despite recognising their significance for clinical distribution - we have chosen to exclude OOP costs from our model. Our reasoning for this is fourfold:

1. We are primarily interested in policy settings around public participation in healthcare funding, particularly the social price **S**. This is effectively independent of OOP costs;
2. Within this paper, we seek to directly compare the baseline cost of public and private delivery of services, which is not possible if we include discretionary spending;
3. Recognition of OOP costs is implicitly reflected in the means-testing of the PHI rebate, which progressively reduces the value of **S** for wealthier consumers.¹³ This may in practice magnify the individual consumer surplus, but it does not change the base price; and,
4. The vast disparity of OOP costs across Australia, and the absence of reliable data on individual expenditure devalues this as an analytical factor.

Finally, we note that there is an element of OOP costs which has a direct impact on the setting of **S** for any course of treatment. While governments hope for a certain percentage (and a certain socio-economic group) of Australians to receive both public hospital care and bulk-billed outpatient services, the reach of healthcare budgets is extended by relying on a reasonable percentage of patients to pay an incremental fee for each attendance.

It may be the case that the OOP costs in some surgeries reflect the difference between the mean MBS payment and the mean price of surgery in public hospitals (see data tables in Appendix C). However, anecdotal evidence suggests these costs are independent and subject to intangible factors, such as individual surgeons' reputations.

This is not quite the same as the consumer surplus, which is highly variable. What occurs in this case is that governments may set **S** at slightly lower than the average cost of services (including expected profits), knowing that the average incremental compensation required from patients is manageable.

¹⁰ 1.7 separations per 1000 population compared to 0.8. Australian Institute of Health and Welfare (AIHW) (1), Admitted Patient Care 2016-17: Australian Hospital Statistics, (Canberra: 23 May 2018), p.179

¹¹ AIHW (2), Australia's hospitals 2016-17 at a glance, (Canberra: 27 June 2018), p.36

¹² See for example: <https://www.smh.com.au/healthcare/over-40000-the-staggering-difference-surgeons-charge-for-prostate-cancer-procedure-report-shows-20170815-gxwdq7.html> Downloaded October 2018

¹³ There is a complicating issue here where insured patients are still able to access public healthcare at no cost, but we would anticipate this is of lesser interest to cancer patients



We distinguish this as an access component, rather than a consumer surplus increment. It will in practice be a low modal charge across all markets, reflecting the difference between S and the actual baseline price P' of delivering surgery, radiation therapy or other medical services.

Part of the access component is the difference between the MBS payment and the scheduled fee, which is typically 25% of the scheduled fee, but this is often not the full access payment (the MBS fee is still often below the marginal cost of service delivery).

An example of this is the typically small OOP cost of radiation oncology.¹⁴ Notably, in our calculations below, we have used the full scheduled fee, rather than the reduced benefit paid (100% rather than 75%).

Treatment of Fixed Costs

Our analysis is based on expenditure which would not occur but for an individual cancer patient. This is the variable cost of medical services.

Specifically, this does not include:

- Any amortisation of construction and fitout costs for hospitals. This is either funded by specific grants and allocations in the public sector, or by a combination of public and private support in the private sector. Similarly, we do not include any allocation for cost of capital in either case;
- Accordingly, for radiation oncology, which is predominantly an outpatient service, we do not consider expenditure on either location infrastructure (entrances, offices and bunkers) or to equipment funded under the Radiation Oncology Health Program Grants Scheme (ROHPG).¹⁵ While the latter has historically been paid on a per-service basis, its rationale is to fund capacity, rather than treatment; and,
- We allocate no cost for administration, public health system management or reporting and billing. While these involve human capital, they are effectively fixed costs, independent of how many procedures take place.

Removal of these costs permits us to make a direct comparison of cost-of-service and efficacy between different modes of cancer treatment, without considering sunk costs. This is also consistent with our view that there are no savings available on fixed costs: if a procedure does not take place, the infrastructure and equipment do not cost any less

¹⁴ See for illustration: <https://www.genesisicare.com/au/treatment/cancer/payments-oncology/>

¹⁵ <http://www.health.gov.au/internet/main/publishing.nsf/Content/health-roi-hpg-overview-index.htm>



Unplanned Readmission

One cost which could be included in surgery – particularly where there is a choice of treatment modes – is the expense of unplanned readmission. This is both a direct cost, and a welfare loss through occupation of a bed which would otherwise be available to someone on a waiting list.

The argument could be made that this should be added to the total cost of surgery for the relevant condition: an example is that in the case of prostatectomy, for Australian hospitals there are approximately 20 readmissions per 1,000 surgeries (2%) within 28 days of original surgery.¹⁶

However, we have taken the view that these are separate expenditures, equivalent in a sense to the cost of nosocomial infections, and not part of the original procedure. While it is possible that they are avoidable in some cases, we do not have insight into how much of this expenditure is simple variance.

Accordingly, these are not added to the costs of our model. Given that some of these data may also be captured under recurrence statistics, we believe this supports the robustness of our model.

Staff Costs

Costs of staffing are a critical component of all medical service prices. These occur in various ways, including staffing associated with direct procedures, and staffing associated with care and management in hospital.

These costs are typically not directly passed on to the patient, and we have accounted for them in our model as follows:

- For radiation oncology – which is an outpatient activity - staff costs include radiation oncologists, medical physicists and radiotherapists. These are expected to be covered by either:
 - The National Weighted Activity Unity (NWAU), which is a fraction or multiple of the National Efficient Price (NEP) determined by the Independent Hospital Pricing Authority¹⁷ for a single treatment (see explanation below);
 - In the case of a private provider, by the MBS scheduled fee;
 - Similarly, for planning, either the NEP component or the MBS fee;
- For surgery, the equation is often more complex. This will include:
 - Payment for nursing staff, which will either be:
 - Included within the modified NEP for the particular procedure, including both for surgery and peri-operative care; or,
 - Included in the PHI payment for hospital accommodation;

¹⁶ AIHW (2), p.32

¹⁷ See <https://www.ihsa.gov.au/publications/national-efficient-price-determination-2018-19> This is discussed further below



- Payment for the surgeon, which is in either:
 - The mean national aggregate price identified by IHPA; or,
 - The MBS fee;
- Payment for other surgical staff via the same two options, including:
 - The anaesthetist; and,
 - Any surgical assistant.

The key difference here is in multiple payments for surgery, plus accommodation and care costs in hospital.

Other Variable Costs

There is a series of other costs associated with cancer treatment which are excluded from our model. These include:

- General practitioner presentations;
- Pathology, including blood and biopsy;
- Radiology, except CT scanning for radiation therapy planning;
- Dispensing fees; and,
- Chemotherapy costs, including medicines and medical oncologists.

The first three of these are excluded because they are costs of diagnosis and general disease management, which may be independent of selected clinical pathways. Accordingly, they do not contribute to the costs of either surgery or radiation therapy.

Medicines as an issue are more complicated. As a general rule, the prices of pharmaceuticals are costed according to assessed increases in life expectancy in terms of QALYs. The algorithm here is calculation of the incremental cost of expected return (ICER) (taking into account both the incremental cost of the medicine and any increased on-costs). Where the ICER < \$50,000 per QALY (as a general rule) then the medicine is efficient and suitable for listing on the Pharmaceutical Benefits Scheme (PBS).¹⁸

The actual social cost to the Government for individual pharmaceuticals is somewhat opaque, due to confidentiality arrangements between the Government and medicine sponsors. There is also no true private market, as the scale and scope of the PBS effectively crowds out any alternative providers:

¹⁸ The UK National Institute for Health and Care Excellence (NICE) uses a threshold range of £20,000 to £30,000 per QALY gained. See: NICE, *Guide to the methods of technology appraisal*, 2013: NICE. Available from: <https://www.nice.org.uk/process/pmg9/chapter/foreword>. Although no explicit threshold has been acknowledged by the Australian Government, an analysis of decisions by the Pharmaceutical Benefit Advisory Committee stated that “PBAC decisions in the past have shown that the ICER is of the order of \$50,000”. See: A. Lowe, S. Dyson, “New therapies for advanced cancers: can our society afford them? Is it ethical to deny patients access to them?”, Actuarial Institute 2013 Actuarial Summit, Institute of Actuaries of Australia, Sydney, Australia (2013).



insurance contribution to medicine costs is very small. These issues make it difficult to draw a direct comparison.

However – based on our consultations as part of this study – it seems that selection of chemotherapy does not affect other clinical choices. It may be that there is a choice between adjuvant therapies in some cases, based on robustness of the patient.

But if we consider the case of prostate cancer, use of chemotherapy does not appear to affect the choice of whether to undertake surgery; and in lung, breast and similar cancers, the high prevalence of multidisciplinary teams limits conflict between surgeons, radiation oncologists and medical oncologists.

Public Hospital Data and the NEP

During the Rudd Government, the Commonwealth moved towards compensating State-Government hospitals via Activity-Based Funding (ABF). This means States are now funded on the basis of procedures in hospitals, rather than for capacity. This is intended to create some alignment between public and private practice, but more importantly offers incentives for efficiency, and reduction of waiting lists. The pricing for ABF is governed by the Independent Hospital Pricing Authority (IHPA).

Since its establishment, IHPA has undertaken significant work towards a nationally consistent approach to ABF. IHPA determines the annual National Efficient Price (NEP), providing ‘a price signal or benchmark for the efficient cost of providing public hospital services’.¹⁹ The mean cost for any given DRG is then expressed as a multiple or fraction of the NEP, called a National Weighted Activity Unit (NWAU).

Amongst other applications, this is useful in comparing the relative efficiency of public and private hospital services.

For this project, we have obtained the actual mean price and standard deviation for our five DRGs from IHPA. This is from the most recent national aggregate price data and does not represent the pricing in any specific jurisdiction. We have then undertaken a separate series of Monte Carlo analyses (see Appendix C) to check the consistency of this with expected values for each DRG.

The IHPA data we have used for each tumour stream is from a set where the principal diagnosis is the same as the surgical DRG.

There is an important observation here which is clear from our data in Appendix C. This is that the social price of public hospital treatment is generally substantially higher than the social price of private surgery. This is a consequence of our model, particularly its exclusion of OOP costs from private surgery.

We know from successive Productivity Commission studies that the relative efficiency of public and private hospitals on a case mix-adjusted basis is almost in parity.²⁰ This suggests that we are not comparing the same total costs between public and private hospitals. In the case of surgery, the most likely explanation remains cost-shifting.

¹⁹ Independent Hospital Pricing Authority, ‘What we do’. <https://www.ihsa.gov.au/what-we-do>

²⁰ Productivity Commission. (2009). Public and Private Hospitals, Research Report. p.102



Data Issues

Our paper is based on publicly available data, as we have been unable to access some preferred data sets over the course of this study.

In particular, this would be improved with more detailed access to the underlying data available to the IHPA. Unfortunately, this is not readily available as it is collected jointly between the States and the Commonwealth, which presents insurmountable privacy issues. This paper will be shared with multiple Governments and we hope to have access to more granular data for future studies.

Outputs of the Government's review of OOP costs will be particularly important here.

We note that our principal outcome datum is rate of recurrence (though we have had regard to life expectancy in our subsidiary willingness-to-pay analysis). We have selected this over life-expectancy for a range of reasons, of which the main three arguments are:

1. Recurrence is the main event which patients are seeking to avoid. Absence of recurrence is consonant with cure;
2. Because life-expectancy permits a measure of recurrence, to which further treatment would be added, this would require additional costs to be included; and,
3. There is a convergence between life-expectancy following cancer and general life tables over the longer term, so it can be an ambiguous gain.

This is an iterative paper, which will be improved by incremental data access, and also presents a model which can be easily replicated for extra tumour streams.



Methodology and Results

Overview

We use a common model across five cancers. This is described in greatest detail in the following section on breast disease, and the results of the model are outlined for all five tumour streams.

The outcomes are highly sensitive to whether surgery is a primary, or secondary (adjuvant) therapy. In the former case, we should expect a large part of any outcome benefit to be captured by surgery, with adjuvant radiation therapy facing a smaller incremental benefit. An example is in curative breast cancer treatment, where surgery is a *sine qua non* of any combination therapy. This has a radical effect on formal measures of comparative economic efficiency, but does not mean that additional radiation is not cost-effective.

Breast Cancer: Cooperative Therapy Benefits and Pricing

For breast disease – given that surgery is almost universally the primary therapy, we have considered the incremental benefit of radiation therapy compared to its incremental price.

Consequently, we have looked at three interrelated questions around the cost-benefit of breast treatment, viz.:

1. Treatment within a public hospital;
2. Treatment within a private hospital; and,
3. Patient willingness to pay.

The data on each of these is provided in Appendix C, and we discuss our findings below.

Breast Surgery in Public Hospitals

The first set of calculations in Appendix C describe the costs of treating breast disease in public hospitals. These are based on best-available data in relation to current treatment.

The calculation of cost-benefit analysis for different medical options relies on first calculating the ratio of benefits between treatment pathways. The fundamental question here is to what extent one proposal dominates another.



In looking at this question, we reviewed a range of recent literature^{21 22 23}, and have been guided heavily by John Boyages’ 2017 study²⁴, plus extensive data from CCORE^{25 26}, to provide notional benefits across seven presentations.

We have discounted the option of mastectomy with no nodes, as this appears to be an outlier in current surgical practice.

This provides us with seven pairs of hazard ratios for recurrence of primary breast cancer. The ratio of gains here is calculated as:

$$\Delta R_{BreastPublic} \frac{Reduction\ in\ Hazard_{Surgery+Radiation\ Therapy}}{Reduction\ in\ Hazard_{Surgery\ Only}}$$

This is compared to a notional risk for no treatment, or observation only. It is a conservative measure, which recognises that the use of surgery prior to radiation therapy captures most of the reduction in recurrence, which then allows us to consider the relative value of adding radiation therapy.

This is then compared to the ratio of costs, which is given by:

$$\Delta C_{BreastPublic} \frac{Cost_{Surgery+Radiation\ Therapy}}{Cost_{Surgery\ Only}}$$

From an efficiency perspective, we consider this as a two-step model, where:

B = Fixed budget for breast cancer

P = Population with breast cancer

C_S = Cost of surgery for breast cancer

C_{S+RT} = Cost of surgery plus radiation therapy for breast cancer

R_S = Recurrence rate with surgery only, and,

R_{S+RT} is the Recurrence rate with combination therapy,

²¹ Vinh-Hung, Vincent & Verschraegen, Claire, “Breast-Conserving Surgery With or Without Radiotherapy: Pooled Analysis for Risks of Ipsilateral Breast Tumor Recurrence and Mortality”, *Journal of the National Cancer Institute*, (January 21, 2004: 96(2))

²² Sheu, Tommy, Buchholz, Thomas A & Smith, Benjamin D, “Lumpectomy With Radiation Versus Mastectomy for Early-Stage Breast Cancer: Value-Based Treatment Considerations”, *Am J Hematol Oncol.*, (2017: 13 (11):16).

²³ Tailby, Ellen & Boyages, John, “Conservation surgery and radiation therapy in early breast cancer – An update”, *Australian Family Physician*, (RACGP, April 2017: 46(4))

²⁴ Boyages, John, “Radiation therapy and early breast cancer: current controversies”, *Medical Journal of Australia*, (September 2017: 207(5)), particularly Table 1, p.217

²⁵ Barton, Michael et al, Disease Prevalence from Review of Optimal Radiotherapy Utilisation Rates, Ingham Institute & CCORE: prepared for the Australian Government Department of Health and Ageing (March 2013), particularly Table 2, p.55 on Incidence of Attributes of Breast Cancer

²⁶ As this is our primary study to establish our model, we have had reference to the largest number of gain studies, of which others are listed at Appendix B



Then looking at the number of people with breast cancer after ten years from the initial population, we have two sets of:

$$\left(P - \frac{B}{C_{S+RT}}\right) + \frac{B}{C_{S+RT}} R_{S+RT}$$

and,

$$\left(P - \frac{B}{C_S}\right) + \frac{B}{C_S} R_S$$

The condition in which the former dominates the latter is:

$$\frac{B}{C_{S+RT}} (R_{S+RT} - 1) < \frac{B}{C_S} (R_S - 1)$$

or,

$$\frac{1 - R_{S+RT}}{1 - R_S} > \frac{C_{S+RT}}{C_S}$$

Again, this is a comparison of total cost to surgery only, rather than a simple comparison of radiation and surgical costs. The latter would be deceptive, as we are interested in total cost-benefit, and do not have strictly competing options to compare.

This methodology is used for the following four tumour streams, though in the remainder there is a comparison of substitutable rather than incremental expenditure, which simplifies the comparison.

Radiation Therapy: Two Prices

For the costs of radiation therapy in both public and private hospitals, we have calculated upper and lower limits, which are variously:

- A combination of intensity modulated radiation therapy (IMRT) and image-guided radiation therapy (IGRT), which are the more expensive contemporary options; and,
- Three-dimensional conformal radiotherapy, which is the older option.

There is a substantial difference between the MBS pricing of these two options, particularly in planning and dosimetry. The extra benefit of IMRT is described as follows: "IMRT is a treatment advance that allows us to modulate the intensity of the radiation dose within a given radiation field. This means that the distribution of the radiation dose can be sculpted more finely around targets of interest while sparing more normal tissues."²⁷ This is particularly important in minimizing side-effects.

²⁷ <https://www.uclahealth.org/radonc/imrt-igrt>



We have also used a left-skewed distribution based on consultation regarding number of attendances. These are outlined in the following table, which is provided, along with Table 2 for illustrative purposes.²⁸

Table 1: Public and Private Costs of Radiation Therapy

MBS RADIATION - not IMRT					
	MBS ITEM	BENEFIT	Units		
Consultation	104	\$86.85	1	1	1
Field Setting/Simulation	15553	\$710.55	1	1	1
Planning	15559	\$866.55	1	1	1
Treatment + additional field	15221/15266	\$97.60	15	25	30
Verification	15700	\$45.95	1	1	1
	TOTAL COST		\$3,173.9	\$4,149.9	\$4,637.9
MBS RADIATION - IMRT					
	MBS ITEM	BENEFIT	Units		
Consultation	104	\$86.85	1	1	1
Field Setting/Simulation	15555	\$710.55	1	1	1
Planning	15565	\$3,313.85	1	1	1
Treatment	15275	\$182.90	15	25	30
Verification	15715	\$76.00	1	1	1
	TOTAL COST		\$6,930.8	\$8,759.8	\$ 9,674.3

As noted in the table, we have assumed a constant mean of two fields for each episode for each patient. We appreciate this varies between cancers. This number has been identified as a baseline in consultation with advising oncologists, and the addition of further fields or a distribution thereof will lead to only a trivial change in our results. In particular, it makes no difference to the cost of IMRT treatments, for which there is a single attendance fee.

These are then modelled according to our distribution of treatment attendances to provide mean costs for comparison with surgery only.

Surgery Pricing

As discussed, our prices of public sector surgery are supplied by IHPA. We have only slightly modified these by calculating P0, P95 and P100 to complement supplied data.

²⁸ For reasons of space, we have not outlined all pricing constructions in this paper, but they are available upon request, and are modelled in Appendix C.



For the private sector, we have: allocated bed days consonantly with IHPA data; have allocated other hospital and anaesthetics costs; and have calculated an average surgical price per the following table.

Table 2: Item Distribution in Breast Surgery

Item Number		Number of Services in 2017-18	Scheduled Fee
31509	BREAST, MALIGNANT TUMOUR, open surgical biopsy of, with or without frozen section histology (Anaes.)	57	\$346.75
31512	BREAST, MALIGNANT TUMOUR, complete local excision of, with or without frozen section histology (Anaes.) (Assist.)	8,279	\$650.15
31516	BREAST, MALIGNANT TUMOUR, complete local excision of, with or without frozen section histology when targeted intraoperative radiotherapy (using an Intrabeam® device) is performed concurrently, if the requirements of item 15900 are met for the patient (Anaes.) (Assist.)	12	\$867.00
31519	BREAST, total mastectomy (H) (Anaes.) (Assist.)	3,604	\$736.05
31524	BREAST, subcutaneous mastectomy (H) (Anaes.) (Assist.)	2,809	\$1,040.25
	TOTAL SERVICES	14,761	
	AVERAGE FEE		\$744.36

For our model, these are distributed in a monte carlo simulation to finalise the costs ratio.

Again, as noted above, we do not include out-of-pocket costs in this analysis. We note that this is particularly conservative, given variation in surgery costs, while it is estimated that 80-90% of radiation services may be covered by the MBS .



Results and Discussion

The full calculations are present at Appendix C, but core outputs are summarized below. We also provide confidence interval calculations and standard deviation. A full set of gain and cost-benefit data for all tumour streams is found at Appendix A.

Table 3: Cost-Benefit Ratios Between Breast Surgery and Surgery Plus Radiation Therapy

Location	Ratio of Gains	Cost-Benefit Ratio (3DCRT)	Cost-Benefit Ratio (IMRT)
Public	1.216	0.824	0.620
Private		0.535	0.332

Several conclusions may be drawn here. First, it is clear from the ratio of gains that the combination of surgery plus radiation dominates surgery only, which is expected, but reassuring. There is a statistically significant reduction in risk of cancer recurrence with radiation in all included presentations.

Second, the cost ratio is higher than the benefits ratio (so the cost-benefit ratio is less than 1). As noted above, this is expected where the majority of recurrence benefit is captured from the initial surgery.

In terms of pure economic theory, it could be argued that these data suggest that within a finite health (and general) budget, more money should be spent by Government buying surgical services, and potentially less on radiation. However, this would be a nonsense. It assumes that there is an infinite supply of surgery and operating theatres, which from what we observe in demand-driven OOP pricing, is clearly not true.

Equally, it fails to recognise our approach to managing waiting lists, wherein patients who have exigent need for cancer treatment are highly confident of receiving it.

Further, it discounts the absolute value of radiation therapy, which is discussed in the section below on willingness to pay.

We note some caution here: this is a marginal difference, and the actual pricing of both surgery and radiation in public hospitals is highly variable: it may be that these ratios converge, or even cross in some cases. This is illustrated in the more granular costing given in a recent study commissioned by IHPA²⁹.

Looking to the private sector, the common ratio of gains with the public sector means that surgery plus radiation continues to dominate surgery, which is important (see the following section).

None of this means that radiation therapy is overpriced or inefficient, but rather that the *public* contribution to surgery in the private sector is comparatively efficient. While we have excluded capital

²⁹ PriceWaterhouseCoopers, A Review and Costing Study into Radiotherapy Services: Final Report, Prepared for the Independent Hospital Pricing Authority, (September 2013), p.31



costs from our model, we suspect that this apparent relative efficiency is in part because of the radically different economic models between surgery (variable users of infrastructure) and radiation oncologists (effectively custodians of substantial capital investment). In the latter case, there is less capacity to cost-shift from the public to the private purse, which is effectively the difference between the public and private sector prices here.

Willingness to Pay

Moving from a comparison of Government subsidies, we look at what the consumer should notionally be willing to pay for radiation therapy in the case of breast cancer. 'Willingness to pay' (WTP) is a common tool used in economics to consider direct cost-benefit. Moving away from the social price set by the Government, we ask whether the benefit to the consumer dominates the social price.

In this, we look at the current Australian general QALY value of \$50,000. This is in itself a type of WTP measure, based on the annual value of a life. While there are elsewhere higher values of a QALY based on - for example - apparent willingness to forego wages to fund workplace health and safety, the \$50,000 measure is more direct: in broad terms, it is the annual mean contribution of working Australians to GDP, discounted by the marginal excess burden of taxation³⁰.

While this is a government figure, given that tolerance for taxation is politically filtered, and we use this datum for alternative or adjuvant health pricing (e.g. for medicines), it is a useful baseline.

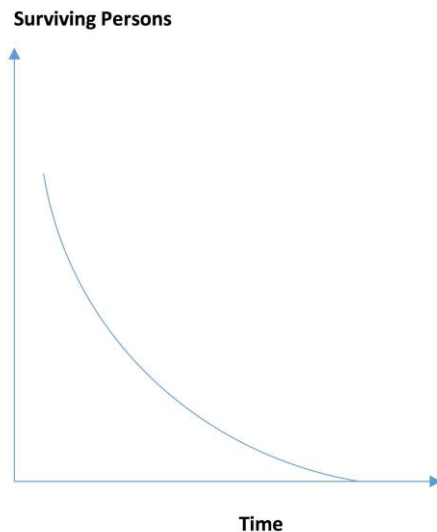
In the third set of calculations within Appendix C, we look at how the incremental cost of radiation for breast disease compares to the expected value in terms of QALYs.

It is important here to understand that all life expectancy tables for patients with cancer follow an exponential form:

³⁰ This is a measure of distortion to the commercial economy caused by different bases used for taxation. It allows us to distinguish between government receipts, and their cost to the economy.



Figure 2: Life Expectancy Over Time (Survival Curve)



This is an exponential distribution, which follows the shape:

$$\lambda e^{-\lambda t}$$

This gives us a cumulative distribution function of:

$$1 - e^{-\lambda t}$$

With a mean of:

$$\frac{1}{\lambda}$$

And a variance of:

$$\lambda^{-2}$$

We note that cancer survival curves sometimes show gains into multiple decades. However we have used a more conservative decay rate (lower λ) as we argue that at two decades, these curves converge with normal life expectancy (death tables).

So, looking conservatively at 15 years after treatment, we find a 25.2% recurrence rate, where:

$$\lambda = -\frac{L_n(1 - 25.2)}{15}$$

The data from here are shown in Appendix C, but the key takeout is that for the various incremental prices we provide, patients at 15 years receive an estimated incremental 0.31 years of life attributable to adjuvant radiation therapy after surgery.



At a nominal QALY of \$50,000 per year, this equates to a value discounted to current dollars of \$15,593.05. This is substantially higher than the actual cost of radiation therapy in all cases, so the addition is exceptional value for the consumer.

Prostate Cancer: Competitive Therapy Benefits and Pricing

In the case of prostate cancer, there is a direct substitution available between surgery and radiation oncology. This allows us to make a direct cost-benefit comparison, rather than relying on cumulative benefit, as for breast disease.

Again, we have reviewed a volume of literature in calculating our gains for radiation and surgery treatment of prostate cancer,^{31 32 33} but have looked most closely at Gordon et al's recent data.³⁴

In general terms, we regard the outcomes from surgical and radiation treatment of prostate cancers as sufficiently equivalent to call them equal. This takes into account:

- Some slight differences in non-recurrence outcomes. From consultation, we are advised that surgery is more likely to have incontinence and impaired sexual performance effects, whereas radiation presents a small probability of bowel issues (these are patient choices). Looking at potential complications, the estimated disability impact (disutility) for each is:
 - 10% for incontinence³⁵; and,
 - 5% for impaired sexual performance;
- In the other direction, and noted in our Appendix C, there is also a marginal difference in recurrence, of:
 - 1% for surgery; vs
 - 2% for radiation therapy.

These last data are close enough to be treated statistically as equal, though our calculated ratio of gains is less than 1.

Our distribution of number of attendances for prostate radiation is again left-skewed, with lower and upper limits of 20 and 39 around a modal series of 37 events.

³¹ Hamdy, Freddie C et al, "10-year Outcomes after Monitoring, Surgery, or Radiotherapy for Localized Prostate Cancer", *The New England Journal of Medicine*, (October 13, 2016: 375)

³² AIHW (3), *Prostate Cancer in Australia*, (Canberra: November 2013), <https://www.aihw.gov.au/reports/cancer/prostate-cancer-in-australia/contents/summary>

³³ Lennernäs et al, "Radical prostatectomy versus high-dose irradiation in localized/locally advanced prostate cancer: A Swedish multicenter randomized trial with patient-reported outcomes", *Acta Oncologica*, (2015: 54(6))

³⁴ Gordon, LG et al, Estimating the healthcare costs of treating prostate cancer in Australia: A Markov modelling analysis, *Urology & Oncology*, (March 2018: 36(3))

³⁵ See http://www.who.int/healthinfo/global_burden_disease/daly_disability_weight/en/



Our cost-benefit results for prostate cancer are as follows:

Table 4: Cost-Benefit Ratios Between Prostate Surgery and Primary Radiation Therapy

Location	Ratio of Gains	Cost-Benefit Ratio (3DCRT)	Cost-Benefit Ratio (IMRT)
Public	0.985	1.548	0.740
Private		0.961	0.460

Here we see that traditional radiation therapy for prostate cancer is highly cost-effective in the public sector, and IMRT-based therapy is close to parity.

Again, the social price of radiotherapy in the private sector is notionally higher than that of surgery. However, given what we know about OOP costs in prostate surgery, this is only part of the picture. In short, what we are using for price is not the total price choice which would typically be faced by a patient with prostate cancer.

What appears to be happening here is that the higher costs of new technology (e.g. robotic prostatectomy) are being passed on to the patient, whereas for radiation therapy, new IMRT/IGRT costs are substantially covered by MBS benefits.

At the same time, the price of IMRT if used instead of surgery in a public hospital is sensitive to the lower rate of robotic prostatectomy in the public setting, so it is unlikely to be a fair comparison.

This is an important issue. It argues for cost-shifting to the private sector in prostate, and prospectively some of the other surgeries examined below. This does not occur in radiation therapy, where there are new and increased MBS benefits for IMRT. This is not an equitable situation.

Addition of OOP Costs

As an additional exercise, and permit comparison of actual rather than just social costs, we have reworked our model to include a range of potential OOP costs for surgery. The outcomes of this are presented in Table 5 below.

There are three key assumptions here, viz.:

1. The social price of radiation therapy is increased universally by 15%, based on the advice that 80-90% of costs are covered by the MBS;



2. We have a range of potential OOP increments for the surgery, at: \$5,000; \$10,000; \$15,000; and \$20,000. OOP costs of this level are reported across all cancers³⁶, though we have no insight into their national frequency or distribution; and,
3. There is no change in the ratio of gains. While consumers may presume that a higher OOP charge is consistent with a higher reduction in the likelihood of recurrence, there is no evidence of this.

The latter point is consistent with our view that OOP pricing is essentially economic opportunity, rather than quality discrimination.

Table 5: Cost-Benefit Ratios Between Prostate Surgery and Primary Radiation Therapy with OOP Costs

Location	Ratio of Gains	Surgical OOP Charge	Cost-Benefit Ratio (3DCRT)	Cost-Benefit Ratio (IMRT)
Private	0.985	\$0	0.961	0.460
		\$5,000	1.937	1.065
		\$10,000	3.037	1.670
		\$15,000	4.136	2.271
		\$20,000	5.234	2.878

What is immediately obvious here is that with even a modest addition of OOP costs for surgical services, the relative cost-benefit of radiation therapy is radically changed. For a referrer and a consumer indifferent to other clinical or personal features of the diagnosis, radiotherapy would now be preferred. This is the comparison faced by any consumer, whether or not they are fully aware of their options.

Salvage Radiotherapy

As well as the individual choice of surgery *or* radiotherapy for primary prostate cancer, we have looked again at the potential addition of radiation to surgery, to minimise the prospect of recurrence.³⁷

This is for those men who show recurrence of cancer after 5 years post-prostatectomy, in elevated levels of prostate-specific antigen (PSA).

³⁶ Gordon, Louisa G et al, "Out-of-pocket medical expenses for Queenslanders with a major cancer", *Medical Journal of Australia*, (11 June 2018, 208(11)). <https://www.mja.com.au/journal/2018/208/11/out-pocket-medical-expenses-queenslanders-major-cancer>

³⁷ For this section, particularly see: Trock, Bruce J et al, "Prostate Cancer-specific Survival following Salvage Radiotherapy vs Observation in Men with Biochemical Recurrence after Radical Prostatectomy", *Journal of the American Medical Association*, (June 18, 2008: 299(23))



This uses the same form of calculation as our WTP for breast radiation, but in this case, we have an incremental benefit of 1.05 years. This leads to an expected value (WTP) of \$52,619.04, compared to costs of \$4,839 or \$10,039 depending upon technology.

Therefore salvage radiotherapy is highly cost-efficient. This may be used as a proxy for radiation therapy overall, which will – as with surgery – be cost-efficient when compared to willingness to pay.

We have not detailed WTP analysis for the final three tumour streams, but it is positive in all cases.

Lung Cancer

Appendix C shows our calculations for Lung Cancer treatment. We are looking again here at a direct comparison (substitution) between surgery and radiation therapy for early-stage non-small cell lung cancer.^{38 39}

Again, there is close to parity in the hazard ratio (from which we derive the ratio of gains) for this tumour stream. This again argues for full information availability to patients, but we note from earlier in this paper that close to 100% of lung cancers are referred to multidisciplinary teams.

We have used a very narrow distribution of attendances from 31 to 33. Our data are as follows:

Table 6: Cost-Benefit Ratios Between Lung Surgery and Primary Radiation Therapy

Location	Ratio of Gains	Cost-Benefit Ratio (3DCRT)	Cost-Benefit Ratio (IMRT)
Public	0.933	2.327	1.120
Private		0.929	0.447

Here we can see some substantial cost efficiency in the public sector. However, it is our expectation that the universal use of multidisciplinary teams will lead to appropriate clinical selection.

Nonetheless, it is of concern given these data that recent reports suggest no increase in uptake of radiotherapy in Australia over the last decade.⁴⁰

While there is still a notionally greater cost-benefit in the private sector, this accounts for a very small percentage of lung cancer surgery, and we again note the absence of OOP costs from our calculation. Radiation oncology is cost-efficient in all the other cases shown in Table 5.

³⁸ See particularly Chen, Hanbo et al, “Stereotactic Ablative Radiation Therapy Versus Surgery in Early Lung Cancer: A Meta-analysis of Propensity Score Studies”, *International Journal of Radiation Oncology*, (2018)

³⁹ Puri, Varun et al, “Treatment Outcomes in Stage I Lung Cancer: A Comparison of Surgery and Stereotactic Body Radiation Therapy (SBRT)”, *Journal of Thoracic Oncology*, (2015 December, 10(12))

⁴⁰ Oar, A. et al, “Has lung cancer radiotherapy utilisation (RTU) changed over time in NSW, Australia?”, presentation supplied by authors



Cancer of the Cervix

For comparison of surgical and radiation therapy options for cervical cancer, we rely on Landoni et al, as confirmed by a recent Cochrane review.^{41 42 43}

The distinctive feature here is that for this type of cervical cancer, the ratio of gains balances on the side of radiation therapy.

We assume no distribution on radiation therapy for cervical cancer with 28 attendances as a single datum. Our data are as follows:

Table 7: Cost-Benefit Ratios Between Cervical Surgery and Primary Radiation Therapy

Location	Ratio of Gains	Cost-Benefit Ratio (3DCRT)	Cost-Benefit Ratio (IMRT)
Public	1.122	2.589	1.236
Private		1.044	0.498

We have no data on practice around this tumour stream. But we expect that the cost-benefit ratio in the private sector will be closer to public cost-benefit ratios if total charges are taken into account.

Cancer of the Head and Neck

This is a highly fragmented area of treatment. Consequently, we have selected early-stage oropharyngeal cancer as a representative tumour.⁴⁴ This is a direct comparison of options, though we note that most patients selecting surgery would then have adjuvant radiotherapy.⁴⁵ We have not included adjuvant radiotherapy in the cost of surgical choice, though this would clearly increase the cost of primary surgery.

⁴¹ Landoni, F. et al. "Randomised study of radical surgery versus radiotherapy for stage Ib-IIa cervical cancer", *Lancet* (1997:350)

⁴² Landoni F. et al, "Randomized study between radical surgery and radiotherapy for the treatment of stage IB–IIA cervical cancer: 20-year update", *Journal of Gynecologic Oncology*, (2017:28(3))

⁴³ Baalbergen A, Veenstra Y & Stalpers L., "Primary surgery versus primary radiotherapy with or without chemotherapy for early adenocarcinoma of the uterine cervix", *Cochrane Database of Systematic Reviews* (2013, Issue 1), Art. No.: CD006248. DOI: 10.1002/14651858.CD006248.pub3

⁴⁴ Gains are based on Catia, Pedro et al, "Surgery v. primary radiotherapy in early-stage oropharyngeal cancer", *Clinical and Translational Radiation Oncology*, (2017)

⁴⁵ Ibid.



Table 8: Cost-Benefit Ratios Between Oropharyngeal Surgery and Primary Radiation Therapy

Location	Ratio of Gains	Cost-Benefit Ratio (3DCRT)	Cost-Benefit Ratio (IMRT)
Public	1.148	4.479	2.168
Private		1.870	0.905

This is the tumour stream from our model which shows the greatest cost-benefit from radiation therapy as a primary therapeutic pathway. Again, this does not take into account clinical issues, such as side-effects, which are present in both options.⁴⁶

Other Economic Benefits

This paper compares the ratio of health outcomes to the ratio of intervention costs, to look at value for money. In doing so, it fails to capture the full schedule of benefits which may accrue from better allocation and utilization of health resources.

We note here some factors which may be suitable for consideration by further studies.

First, throughout this paper and the associated models, we have valued a life-year of any patient according to an accepted QALY price, which is the implicit value for all Australians. However, there is potentially a substantially higher return for those in the workforce. If we look at data from a separate DRG, we find an estimate that the overall loss to GDP from an Australian ceasing participation in the workforce exceeds \$123,000.⁴⁷ It is natural that the economic contribution of working Australians substantially exceeds the national average.

It should be noted that our WTP analysis is relevant here: while we calculate value to the consumer, a similar calculation could also be made across the whole-of-economy participation benefit.

Looking further at consumer value, we note that different healthcare choices may have significantly different individual opportunity costs, particularly with respect to earned income. In particular, where there is a choice between surgery or radiation therapy, patients may choose between:

- A period of hospitalization with a lengthy recovery time at home; or,
- Programmed short absences from work, with no extended recovery time.

⁴⁶ Ibid.

⁴⁷ Schofield, Deborah et al, "The costs of diabetes among Australians aged 45-64 years from 2015 to 2030: projections of lost productive life years (PLYs), lost personal income, lost taxation revenue, extra welfare payments and lost gross domestic product from Health&Wealth", BMJ Open (2017.)



Equally, treatment which does not demand a lengthy recovery period may also permit a reduction in demand for informal care, allowing family members to work who would otherwise be required to assist at home.

Overall, this is an argument for fully-informed patient choice, to address prevailing information asymmetry.⁴⁸

⁴⁸ See for illustration: <https://www.targetingcancer.com.au/2018/07/make-men-aware-of-all-treatment-options/>



Conclusions and Recommendations

This study finds substantial benefit in radiation therapy for five cancers, as well as economic value in both. This is visible both where radiation is an adjuvant therapy, and where it is a substitute for surgery. We note that of this is an argument that surgery or radiation therapy in any case is either overcompensated or overvalued.

However, what our data – combined with current knowledge about OOP costs – suggests is that three intersecting phenomena are occurring which skew the potential choice of radiation therapy. These are:

1. There is significant variance in patient awareness about treatment pathways, which may exacerbated in some cases where the primary carer is incentivized to recommend a particular choice;
2. At the same time, there is strong evidence of cost-shifting from the public to the private purse in the case of some surgeries. This is not the case in radiation therapy;
3. These then intersect, where the social price for surgery in some circumstances may be lower, but the overall cost is higher.

There are public policy questions which arise from this, and which will be more easily understood once the review of OOP costs is complete.

In particular, some thought should be given to what are the welfare costs of this arrangement, and whether it is equitable. Our model can easily be augmented with OOP costs for any surgery or even individual patient, which we expect will show substantially greater value for radiation oncology. This is despite new emerging technologies in both specialties.

At the same time, we note that access to Linacs remains restricted for many Australians, in both urban and regional settings. Where there is a clear cost-benefit to patients of selecting primary radiation, either on the social price or with prevailing OOP costs added, this presents a potential reduction in health outcomes, and an equivalent loss of welfare. This is similarly the case with adjuvant radiotherapy, if we look at willingness to pay.

This is an incremental study, and the model can be updated as new data come to light. We would be pleased to work with interested parties to examine the effects of different prices and other settings.



Appendix A: Schedule of Results

Tumour Stream	Setting	Ratio of Gains	Addition of OOP Costs	3D-CRT Cost-Benefit	IMRT Cost-Benefit		
Breast	Public	1.216 ⁴⁹		0.824	0.620		
	Private			0.535	0.332		
Prostate	Public	0.985 ⁵⁰			1.548	0.740	
	Private			0	0.961	0.460	
				\$5000	1.937	1.065	
				\$10,000	3.037	1.670	
			\$15,000	4.136	2.271		
			\$20,000	5.234	2.878		
Lung	Public	0.933		2.327	1.120		
	Private			0.929	0.447		
Cervix	Public	1.122			2.589	1.236	
	Private				1.044	0.498	
Oropharyngeal	Public	1.148				4.479	2.168
	Private					1.870	0.905

⁴⁹ Comparison between surgery only, and surgery + radiation therapy

⁵⁰ This and all others surgery *or* radiation therapy as primary treatment



Appendix B: Further Gains References for Breast Disease

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Appendix C: Full Calculations

Appendix C is a computerised model for each cancer, which can be accessed upon request. It includes the following excel spreadsheets:

1. RTAG Appendix C - Breast
2. RTAG Appendix C - Prostate
3. RTAG Appendix C - Lung
4. RTAG Appendix C - Cervix
5. RTAG Appendix C - Oropharyngeal