Increase in computed tomography in Australia driven mainly by practice change: a decomposition analysis.

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Highlights

- The drivers behind the increase in computed tomography (CT) are not well characterised.
- As CT is publicly funded through Australia's universal healthcare system, Medicare, an unevaluated increase in use outside of that driven by demographic drivers has potential public health (because ionising radiation is used) and health economic implications.
- In Australia, funded CT procedures are often described by the body site of the CT, rather than the indication for use, as opposed to more contemporary technology like positron emission tomography, where item descriptors are often much more specific.
- We used Australian CT data to explore demographic drivers versus practice change. Change in practice, rather than demography, was the main driver of CT increase.
- This finding invites a prospective effort to specifically define descriptors for publicly funded services, and a discussion of whether/how often retrospective review of previously funded services that are less specifically defined should occur.

Abstract

Background: Funded computed tomography (CT) procedure descriptions in Australia often specify the body site, rather than indication for use. This study aimed to evaluate the relative contribution of demographic versus non-demographic factors in driving the increase in CT services in Australia.

Methods: A decomposition analysis was conducted to assess the proportion of additional CT attributable to changing population structure, CT use on a per capita basis (CPC, a proxy for change in practice) and/or cost of CT. Aggregated Medicare usage and billing data were obtained for selected years between 1993/4 and 2012/3.

Results: The number of billed CT scans rose from 33 per annum per 1,000 of population in 1993/94 (total 572,925) to 112 per 1,000 by 2012/13 (total 2,540,546). The respective cost to Medicare rose from $145.7 million to $790.7 million. Change in CPC was the most important factor accounting for changes in CT services (88%) and cost (65%) over the study period.

Conclusions: While this study cannot conclude if the increase is appropriate, it does represent a shift in how CT is used, relative to when many CT services were listed for public funding. This ‘scope shift’ poses questions as to need for and frequency of retrospective/ongoing review of publicly funded services, as medical advances and other demand- or supply-side factors change the way health services are used.

Key words: computed tomography, computed axial tomography, CT scan, health service utilisation.

Background

Computed tomography (CT) scanning is a commonly used medical imaging technique which takes multiple X-ray images, and assembles them to provide a 3-dimensional image (1). Since its introduction in the 1970s, CT technology has advanced substantially and its added clinical utility has led to increased use in Australia. Organisation for Economic Cooperation and Development (OECD)-collated data for Australia estimated that CT non-public hospital examinations (approximately 75% of the total (2)) increased 32% between 2007 and 2013, from 83.2 to 109.8 CT examinations per 1,000 of population (3). If the increase were due to population increases or change in distribution (i.e. reflective of an ageing population) then increasing counts of CT and associated costs should be proportionate to these changes. Indeed, population ageing is often cited as a major driver of increasing health resource utilisation and costs (4). Changes outside of that expected due to demographic changes would therefore reflect a change in the way that CT is being used. Whilst examining these proportionate changes cannot alone aid judgment in whether any 'change in practice' is appropriate, it would serve to demonstrate changes in the way that CT is being used from the original intention when descriptive service parameters were developed and evaluated, and decisions to provide public funding made. Whilst the potential for 'scope shift' is not unique to CT, it is worth examining CT in particular as, because of the radiation dose delivered in addition to the cost of the procedure, use of CT outside of settings found to be clinical and economically effective has the potential to cause harm, in addition to burden on publicly funded health systems. The absolute risk associated with CT radiation at a population-level is currently not well characterised. Epidemiological studies published to date (5-7) likely over-estimate the risk from CT exposure for adults (8).

However, existing indirect evidence (e.g. (9)) suggests the risk is non-negligible and offers support to the presiding 'as low as reasonably achievable' (ALARA) principle with respect to ionising radiation in medical imaging (10).

Public funding arrangements for CT in Australia

Australia has a fee-for-service model for CT scanning outside of public hospitals, where the Federal Government reimburses private radiology providers for individual services through Medicare. Medicare also funds general practitioner (GP), pathology, other diagnostic, medical specialist and allied health services, with specific item descriptors and the service fee described in the Medicare Benefits Schedule (MBS). The 'benefit' publicly reimbursed to the provider is usually 85% of the listed schedule fee, which the provider can either accept as the total payment, or also charge a co-payment to the patient. CTs are performed at the request of a medical practitioner, often a GP in an out of hospital setting. Services through public hospitals are funded through a combination of state and national funding and are typically not reported by Medicare. Since 1998, recommendations for item listing are made by the Medicare Services Advisory Committee to the Minister for Health, following extensive health technology assessment (11). Prior to this period services were funded without assessment and the legacy of this is that many services have extremely non-specific (if any) descriptors for their intended use. Examples of this include many CT examinations in which the item descriptor merely states the area of the body without any identification of the clinical setting under which the examination has been listed for funding. In contrast descriptors for more recently funded diagnostic technologies, such as magnetic resonance imaging and positron emission tomography, tend to be very specific about the circumstances of their use under public funding, reflective of advances in health technology assessment and concerns about the impact of technological advancement on health budgets over time (12). On 22 April 2015, the Minister for Health announced the formation of a taskforce to review whether more than 5,700 MBS items could be better aligned with contemporary clinical practice and evidence (13). Diagnostic imaging is one of the larger areas for review, due to the number of items and since many descriptors have not been re-evaluated since they were first included on the MBS

The present study and implications for health policy

Previous descriptive studies have quantified the increase in CT use (14-20), including in Australia (21, 22). However, to our knowledge, no study has analysed the proportion of change due to demographic versus non-demographic factors, to infer then change in use potentially outside of that intended when the decision to publicly fund a service was made. Thus in this study, we aimed to find whether the major proportion of change in CT scans and associated costs billed to Medicare was due to population size and structure changes, or else the complement of this (i.e. that explained by 'change in practice')?

Through examining this question for CT in Australia, a broader question of whether this situation is occurring for other health services is posed, especially in publicly funded health systems where descriptors are broad and where indications for use are not clearly characterised. This is especially so in cases where clinical progress may have driven change. Thus, analysis of the demographic versus non-demographic drivers of CT change in Australia is worthy of consideration by policy makers in other settings with similar funding and/or service delivery arrangements.

Methods

Data sources

Population data estimates disaggregated by age, sex and state/territory were sourced from the Australian Bureau of Statistics (23). The estimated population was as at June of the earlier calendar year (e.g. June 2012 for the 2012/13 fiscal year).

CT scan utilisation data were sourced from publicly available Medicare Benefits Schedule (MBS) records, extracting 'Item I2: Computed Tomography' (24). The MBS lists all services eligible for reimbursement through Australia's Medicare programme. Almost all (~99% (2)) of the CT services provided in public hospitals are excluded from these data. These records were categorised by sex, age group and state/territory of service. The quarter and year recorded for a service reflected the time period that the claim was processed by Medicare. Costs are in Australian dollars as at the time of processing.

Decomposition analysis

We analysed six separate fiscal years (covering the period 1 July to 30 June): 1993/4, 1996/7, 2000/1, 2004/5, 2008/9, and 2012/13. The population (P); number of CT scans (E); and Medicare benefit paid (T) were extracted for each time period, excluding two records for which the age group was not known. From the extracted data, the mean number of CT scans per capita (CPC) in each each-specific group j was calculated as: $CPC_j = E_j/P_j$. Similarly, the mean cost per episode (CPE) was be calculated as: $CPE_j = T_j/E_j$, where T_j is the cost of benefit paid for that time period by age-specific group, j. The CPC and CPE were also calculated for the study population overall (i.e. aggregating over all j groups). Sub-analyses were conducted for each sex (comparing each of the years in the original analysis), and for individual state/territories, comparing 1993/4 to 2012/13 only.

The decomposition analysis was based on methods used by Ha and colleagues (25) ; the methods are briefly summarised below and described in detail in Appendix 1. Firstly, we investigated the proportion of the change in the number of CTs that was accounted for by: i) change in population size; ii) change in population distribution and iii) change in CPC. The change in CPC metric acted as an indirect measure of change in practice (i.e. changes in the clinical indications for CT facilitated by technological advancement). One time period was compared to the next successive time period. In addition, 2012/13 was compared to 1993/4, which compares across the entire duration of our data collection.

The proportionate change in CT count was decomposed into three explanations, namely: population growth, age distribution and the CPC metric. To estimate the proportion of change due to population growth, we assumed that both the population age distribution and number of CTs performed per capita for the latter time period did not change from the earlier comparator year. The difference between time periods predicted by holding these factors constant, as a proportion of the actual change in CT count observed, was attributed to population growth. Relaxing the assumption of the age distribution remaining identical between time periods allowed the proportion of change attributable to shifting population distribution to be calculated next. Finally, the proportion attributable to CPC – a proxy for change in practice - was simply the remaining CT growth unexplained by population growth or distribution change.

For the second part of the decomposition analysis, we repeated the approach from part one, but with five explanations for the change in cost, these being: i) change in population size; ii) change in population distribution; iii) change in CPC; iv) change in CT distribution by age group and v) change in CPE. As in the count decomposition, each factor was isolated in-turn to account for the change between compared time periods (see Appendix 1 for further details). The analyses were conducted using Microsoft Excel Version 14.5.5 (Redmond, Washington, United States).

Results

Table 1 shows population and Medicare-billed CT scan counts and costs over the study period. The Australian population increased in size by 29% between 1993 and 2012, from 17.7 to 22.7 million. The population age-distribution between these time periods shifted toward the right; 11.6% of the population were aged ≥ 65 years in 1993, compared to 14.2% in 2012. Over four times as many CT scans were billed to Medicare in 2012/13 than in 1993/4 (2,540, 546 versus 572,925 respectively). This yielded a CPC (per 1,000 of population) of 33 in 1993/4, compared to 112 in 2012/13. Appendix 2 shows CT count and cost data disaggregated by sex and age group. Both the population and CT count in people aged 85 years or above increased markedly over the study period (144% and 1,117%, respectively). The dollar value billed to Medicare in 1993/4 was $145.7 million (~$243 million equivalent at December 2012 (26)); this had increased to $790.7 million by 2012/13. The CPE also increased, from $253 to $311.

The results of the decomposition analysis for Medicare-billed CT scan count are displayed in Figure 1. The majority of the change in CT count was due to change in the CPC (88% from 1993/4 to 2012/13), though this became relatively less important over the study period. Conversely, population growth explained only 12% of the change in number of CT scans performed from 1993/4 to 1996/7, while it explained over a fifth (21.5%) of the change in number of CT scans from 2008/9 to 2012/13. Change in population age-distribution accounted for only a small proportion of the change in CT scan count (3.9% to 8.3%).

The analysis of change in Medicare-billed cost data showed that change in CPC was an important factor explaining the increase in cost over the study period (Figure 2). This was especially so when comparing 1996/7 to 2000/1, where the change in CPC accounted for 79% of the cost increase. However, for the last two years compared, 2008/9 versus 2012/13, the change in CPC accounted for only 45% of the cost increase. During the study period, change in mean CPE became a more important factor in explaining the change in cost, accounting for 37% of the change from 2008/9 to 2012/13.

Separating data by sex showed the male and female population were evenly distributed for the years included in the analysis (proportion female 50.2% to 50.4%), though the proportion of scans on females (53.2% to 54.3%) and associated costs (52.5% to 53.7%) was just over half. The decomposition analysis with data separated for males and females showed similar results to the analysis for both sexes (see Figure 3 (count) and Appendix 3 (cost)).

The analysis by state/territory, provided in Appendix 4, did show variable CT count increases. The lowest proportionate increase in CT was seen in the Australian Capital Territory at 240%, while Queensland saw the most increase at 508%. The results of the state/territory-based decomposition analysis were similar to those for Australia overall.

Discussion

Medicare-billed CT scans and associated costs increased markedly over the period 1993 to 2013. To provide international context within OECD countries, Australia's CT use in 2013 was markedly higher than Finland at 32 per 1,000 population (the lowest), but lower than the highest user per capita, Estonia at 495 per 1,000 (3). Our analysis shows the main factor associated with CT increase in Australia is an increase in CPC, indicative of a change in practice beyond that driven by changes in demography and potentially beyond that for which the initial decision for provide public funding was based upon. However, the importance of population growth as a factor in increasing CT increased over the study period. Likewise, the relative importance of CT cost has increased as a factor in explaining the change in total expenditure over the study period.

CT scan use increased rapidly as technology developed over the study period, as demonstrated by the importance of change in CPC over time. In 1996/7, new MBS item descriptors were added for CT imaging (i.e. new publicly funded CT services) (27); consistent with the high proportion of change from 1996/7 to 2000/1 explained by the change in CPC for both count and cost data. A limitation of the CPC is that it implies one scan per person, which is not necessarily the case. Because the aggregate-level data for MBS-billed CT scans does not identify individual patients, we could not disentangle the impact of multiple scans. Sodickson and colleagues (28) found in a U.S. setting that multiple CT scanning was very common, with a median of 3 scans/person amongst a mixed inpatient/outpatient cohort. The impact of multiple scanning is likely to mean the proportion driven by change in practice is higher than in our estimates, and thus our conclusions are unaltered.

CPE increased in importance as an explanatory factor in the increase in CT cost over the study period. Unlike other MBS services, which are indexed against the wage and consumer price indices each year, medical diagnostic fees have not been routinely indexed since 1998 (27). Changes in schedule fees would thus be expected to account for a portion of change in CPE prior to 1998, but are less useful in explaining change between 1998 and 2013. The change in CPE is thus more likely to be associated with increased use of higher-fee MBS items; this is also indicative of a change in the way CT is used in practice. A recent audit report found a 20% increase in the average benefit paid for diagnostic imaging services between 2005/6 and 2013/14; this is consistent with a 15% increase in CPE from 2004/5 and 2012/13 seen in billing data used in our study. The audit authors' attribute the increase to "growth in the use of higher-end technologies and/or changes in clinical practice" (29). As our study aimed to quantify the proportion of change in CT scans broadly to demographic versus non-demographic changes, we have not isolated individual MBS items. The utility of doing so is slightly reduced by MBS numbers in Australia indicating the site of CT, but not the indication (12). It is possible that such isolation of CT by indication would be more enlightening using data from another setting, such as the United Kingdom, where the reason for GP visits is recorded, which may allow further exploration of CT for specific indications (e.g. lower back pain). Previous work in Western Australia found the greatest changes per 1,000 population from 2006/7 to 2011/12 were for interventional CT (7.3 to 11.4), followed by facial bones (8.3 to 9.7) (2). MBS-billed CT of the spine reduced from 20.8 to 18.8 per 1,000 population (2).

While the proportionate contribution of population size increased over the study period, the change in population distribution explains less than 10% of the change in CT count and cost over all compared time periods included in the analysis, despite a shift to the right. However, this is relative to population growth and non-population size/distribution factors and it is clear that some changes in CT distribution have occurred, including an increase in CT for those aged 85 years or above.

Our study cannot determine if CT increase beyond that driven by increase in population size/ageing is appropriate. Previous Australian work has shown between-provider variation in CT technique and radiation dose, as well as scanning protocols leading to higher doses than reported as being standard in international literature (30). Simpson and Hartrick (31) have assessed the appropriateness of general practitioner-requested thoracic CTs – albeit with a small sample size of 50 – and found the majority (n = 34) to be inappropriate in their view. A larger Australian study (N= 3,533) focused on acute lower back pain found that over a quarter of patients seen by GPs were referred for imaging (6.2% specifically for CT) (32), after the publication of evidence-based guidelines advising against imaging in the absence of specific clinical 'red flags' (33). Aids, such as those developed by the National Prescribing Service

(34, 35) and the Western Australian Department of Health (36), have been designed to encourage appropriate use of CT, and a Medicare Taskforce is currently undertaking a system-wide review of diagnostic imaging (37).

A study using similar data in Australia found that the increase in CT was greater than the corresponding increase in population size from 1994 through 2009, though the relative proportions were not quantified (21). Our study highlights non-demographic factors as the major driver of Medicare-billed CT scan increase over two decades, and the use of routinely collected administrative data is likely to accurately capture actual CT scanning activity in the private sector. The decomposition method is suitable to the population-level aggregate data analysed, as opposed to more detailed multivariable analysis which could have been applied to individual-level data.

This study has several limitations. Firstly, the costs in this decomposition analysis reflect those reimbursed by Medicare and do not include patient co-payments; these ranged from 10% of the total fee in 1993 up to 17% by 2004 (24). The Medicare fee is an important determinant of the fee structure, making it a reasonable proxy for the cost of CT. Secondly, population-level averages may mask variation between providers. Thirdly, the before and after study design meant that the individual factors contained within the 'change in practice' metric are likely to be dynamic over time. While factors other than those isolated would ideally be held constant (25), the way the decomposition analysis has been used in this study is such that the proportion of change accounted for by 'change in practice' is simply the complement of that explained by changing population size and structure change over time. Whilst we have offered several potential non-demographic drivers, the list is not exhaustive.

Finally, data from public hospitals are omitted from this analysis. An earlier cohort study using data from Western Australia found that 74% of CT scans performed from 2006/7 through 2011/12 were billed to Medicare, rather than delivered in a public hospital (2). This analysis found differences between CT in public and private settings. For example, head CT was relatively more common in public hospitals (2). Brady and colleagues (21) also highlight that this proportion of CT performed in public hospitals is higher for children and adolescents, relative to older age groups . The results of this decomposition analysis thus cannot necessarily be extrapolated to CT in all provider settings in Australia.

Conclusion and implications for policy

Changes in the way CT is utilised, more so than changes in demography, have driven an increase in CT services and associated costs billed to Medicare from 1993 through 2013.

Because CT item descriptors are typically by body site, rather than more detailed descriptors for more recently funded techniques such as magnetic resonance imaging and positron emission tomography (12), there is a potential that practice change reflects an increase in scope beyond that intended when the decision to publicly fund was made. Our analysis therefore invites debate on how often or whether retrospective analysis of publicly funded health services is appropriate, and highlights the importance of developing specific descriptors in line with the evidence of (cost)-effectiveness considered via detailed health technology assessment. The method we have used can easily highlight areas where 'scope shift' may have occurred, which may aid to identify areas worthy of more in-depth review. Specific to CT, consideration of the demand- and supply side factors involved in the increase is warranted (for example, the number of CT scanners per 100,000 population increased from an estimated 21 in 1995 to 54 in 2013 (38)), especially given services are delivered by private providers.

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Table 1. Medicare-billed computed tomography (CT) scan count and cost data for Australia.

	1993/4[a]	**1996/7[a]**	**2000/1[a]**	**2004/5[a]**	**2008/9[a]**	**2012/13[a]**
Population[b]	17,667,093	18,310,714	19,153,380	20,127,363	21,498,540	22,721,995
Number of CT scans	575,925	748,756	1,083,189	1,459,958	2,008,071	2,540,546
Mean CT scans per 1,000 capita	33	41	57	73	93	112
Total Medicare Benefit Paid ($)[c]	145,739,758	192,566,931	279,414,712	394,367,896	562,255,248	790,716,566
Mean cost per episode ($)[c]	253.1	257.2	258.0	270.1	280.0	311.2

a. Fiscal year (1 July through 30 June).
b. The estimated population was as at June of the earlier calendar year (e.g. June 2012 for the 2012/13 fiscal year).
c. Cost data are at time of processing (i.e. not inflated to current value).