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Can the US Afford to Ignore Cost-effectiveness Evidence in Health Care?

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1. INTRODUCTION

Compared to many other countries, cost-effectiveness analysis plays a limited role in US health care. The overarching aim of this Office of Health Economics briefing is to consider the current use of cost-effectiveness analysis in the US health care system and explore the potential value of including it in Medicare coverage decisions for medical technology. First, it places US health care spending and performance in an international context. Second, it reviews the current use of cost-effectiveness analysis in the US, considers deep-rooted resistance to it and describes failed attempts to embed cost-effectiveness evidence into decision-making. Third, it reports on published research evaluating the consistency of Medicare coverage policy with cost-effectiveness evidence, and attempts to estimate potential aggregate health gains of doing so. Fourth, it discusses payment reform and comparative effectiveness research (CER) as the policy tools embraced by the US to address health care spending inefficiency. Last, it reviews obstacles to using cost-effectiveness evidence, potential ex-US consequences of its existing limited role, and what the US could learn from other countries.

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1.1 US health care in perspective

The US spends 17.7% of GDP on health care, notably more than the average spend of the Organisation for Economic Co-operation Development (OECD) member countries (9.3%) and the country with the next highest spending (Netherlands, 11.9%) (OECD, 2013). Spending is set to increase further, with estimates that it will reach one fifth of GDP by 2021 (Keehan et al., 2012). But while the total cost of health care is concerning, it is the return from spending that is most problematic. While hailed as the world's best health care system in some quarters, reports suggest that the US health care system performs poorly relative to others across a range of performance indicators (Fuchs, 2013). For example, average life expectancy is lower in the US than in other developed countries (78.7 years in 2011, OECD average of 80.1 years), and if President Obama's Patient Protection and Affordable Care Act (ACA) is not fully implemented, tens of millions of Americans, approximately 15% of the population, will continue to be uninsured (OECD, 2013; 2013).

The US has performed poorly in various global health care system rankings. In 2000, the World Health Organisation published its widely cited rankings, with the US placed 37th (World Health Organization (WHO), 2000). Ranking was based upon 'overall efficiency' with a single composite score calculated from five indicators: health, health quality, responsiveness-level, responsiveness-distribution and fair-financing. The Commonwealth Fund, a US based private foundation focused on promoting a high performing health care system, has ranked health care systems using five criteria: quality, efficiency, access to care, equity and the ability for citizens to lead long, healthy, productive lives. In each assessment, from the first in 2004 through the most recent in 2010, the US health care system ranked unfavourably compared to the other countries considered (Hussey et al., 2004; Davis et al., 2006; Davis, Schoen and Stremikis, 2010).

Given the apparent urgent need to achieve better value from health care spending, reasons why the US has not incorporated cost-effectiveness more fully into decision-making require some inspection. Peter Neumann from the Center for the Evaluation of Value and Risk in Health (CEVR) at Tufts Medical Center in Boston suggests that distrust of government and resistance to government intervention in health care may be deeply engrained in the American psyche and a primary reason for cost-effectiveness evidence's marginal role in the US health care system.

1.2 American exceptionalism

Dubbed 'American exceptionalism', Americans' reluctance to accept rationing or government intervention in health care has deep historical roots. Indeed, it was Thomas Jefferson, a principal founding father, who said, 'that government is best which governs least' (Neumann, 2009). Public distaste for health care rationing was evident in the furore surrounding the US Preventive Services Task Force (USPSTF) – an independent panel of experts that provide evidence-based recommendations for preventive services – revised guidelines for breast cancer screening (Innovation, Bioscience and Growth Team, 2009). The Task Force's recommendation to change the age at which women should be offered breast cancer screening from 40 to 50 was met with public outcry and claims that

it heralded the beginning of unacceptable government rationing (Box 1). The public's distaste of government imposed limits on health care has meant that politicians are loath to advocate for cost-effectiveness, fearing it will be interpreted as encouraging health care rationing. Debate continues to be divisive, illustrated by claims that government intervention to prioritise health care spending would be tantamount to the creation of 'death panels' (Vierra, 2012; Kettl, 2010).

Beyond American exceptionalism, the proposition of using cost-effectiveness evidence more widely in health care has faced opposition from various quarters, including product manufacturers, providers, insurers and health care professions concerned that its use may adversely affect revenue streams and R&D investment. This opposition was apparent in failed attempts to incorporate cost-effectiveness analysis into US Medicaid and Medicare coverage policy.

1.3 Cost-effectiveness evidence's false starts

Notable failed attempts to incorporate cost-effectiveness evidence into decision making are worthy of discussion and remain highly relevant today. The first is the Oregon Experiment, an often-cited example of an attempt to use cost-effectiveness evidence to prioritise health care spending. One goal of the Oregon Experiment was to expand the Medicaid programme, the health care programme for low income individuals and families, to all Oregon residents below the poverty line. The expansion was to be achieved by rationing the Medicaid benefit (Alakeson, 2008). This was accomplished by using cost-effectiveness evidence, along with input from the community, to produce an objective ranked list of technologies (Buist, 1992). The prioritisation met fierce opposition, with claims that the ranking process was neither open nor fair and that the list discriminated against the poor and the disabled (Bodenheimer, 1997; Daniels, 1991). The plan was eventually enacted in 1994, but only after cost-effectiveness evidence had been removed from the process. Why the inclusion of cost-effectiveness ultimately failed has been subject to much debate. It is suggested that a combination of political, legal and ethical factors played a role and that the approach to prioritising technologies was technically flawed and failed to capture public preferences (Jacobs, Marmor, and Oberlander, 1999). Others suggest that a principal reason for failure was the ingrained American exceptionalism noted above (Neumann, 2009).

Medicare is the federal health insurance programme for the elderly (those aged 65 or older) and people with certain disabilities. There have been two failed attempts to include cost-effectiveness analysis into Medicare coverage policy. In 1989 the Health Care Financing Administration (HCFA) argued in proposed regulations that the consideration of cost in coverage policy would 'be a deterrent to coverage of procedures that may be costly, but have little or no impact on improving health outcomes" (in Neumann, 2005, p. 21). However, opposition from industry and consumer groups prevented their release. In the mid-1990s the HCFA attempted to revive the proposed regulations. Again, opposition, this time from profession medical societies, including the American Medical Association and the American College of Physicians, along with the Pharmaceutical Research and Manufacturers Association of America, prevented the final rule from being published (Neumann, 2005). In 1999 the proposed regulation was withdrawn.

Despite the failure of the above attempts to embed cost-effectiveness analysis into decision-making, today, some private and public payers do use cost-effectiveness analysis, albeit in a limited, patchy and inconsistent way.

1.4 Current limited use of cost-effectiveness evidence

In spite of a lack of transparency in the criteria private health plans use to judge coverage of medical technology, it is apparent that some use cost-effectiveness analysis. As part of its guidelines for dossier submission to pharmacy and therapeutics committees, the Academy of Managed Care Pharmacy (AMCP), the national professional society for pharmaceutical care in managed health care markets, provided recommendations on how cost-effectiveness evidence should be presented (AMCP, 2010). WellPoint, the largest for-profit company in the Blue Cross and Blue Shield Association, a federation of 38 US based health insurers, has provided a framework for submitting economic evidence, including guidance for study conduct, e.g. analysis should be performed using a three-year time horizon, and stipulation that claims of budget impact and cost-effectiveness should be specific to the WellPoint insurance environment (WellPoint, 2008). Premera Blue Cross, a non-profit member of the Blue Cross and Blue Shield Association based in Seattle, Washington, uses cost-effectiveness evidence to inform its value-based formulary (Watkins et al., 2011). More cost-effective drugs are placed on lower tiers associated with lower co-pays, with the intent of encouraging use of more cost-effective treatments.

Some public payers also use cost-effectiveness evidence. In addition to monitoring drug usage and cost trends, the Department of Defense Pharmacoeconomic Center conducts pharmacoeconomic analyses to support formulary management, pharmaceutical contracting and informing clinical practice guidelines (Department of Defense, 2013). The Department of Veteran Affairs Health Economic Resource Center has multiple roles, including performing cost-effectiveness analyses and evaluating programme efficiency (Department of Veteran Affairs, 2013). The state of Washington recently implemented a health technology assessment programme that includes review of cost-effectiveness evidence within its remit. One of the programme's stated goals is to make 'state purchased health care more cost effective by paying for medical tools and procedures that are proven to work' (Washington State, 2013).

Medicare is the largest payer in the US, with an estimated annual cost of more than $600 billion, 21% of national health care spending (CMS, 2013b). The administrators of Medicare, the Centers for Medicare and Medicaid Services (CMS), use cost-effectiveness evidence in Medicare in a very marginal way, restricted to the occasional use in coverage determinations for preventive care. For all remaining interventions cost-effectiveness evidence is effectively excluded from CMS's review of the evidence base. Notably, for national coverage determinations (NCDs), i.e. the coverage pathway largely reserved for 'big ticket' interventions, cost-effectiveness evidence is effectively excluded from consideration. In the Guidance for the Public, Industry and CMS Staff, CMS states that 'cost-effectiveness is not a factor CMS considers in making NCDs. In other words, the cost of a particular technology is not relevant in the determination'. (CMS, 2010)

The US health care system is fragmented and decentralised, consisting of a multitude of public and private payers (Cebul, Rebitzer, Taylor and Votruba, 2008; Elhauge, 2010). With such fragmentation, variability in the use of cost-effectiveness evidence is perhaps expected. However, the exclusion of cost-effectiveness from Medicare is notable. Once eligible for Medicare, beneficiaries remain in the programme for the remainder of their lives, which is unlikely to be the case for private plans and it would seem the programme may have much to gain from using cost-effectiveness to help maximise the return from limited available resources.

Medicare is the dominant US payer and is thought to have far-reaching effects, influencing other public and private payers' coverage policies. Given its significance, in a series of papers, my colleagues and I used Medicare as a case study to evaluate the consistency of US coverage policy for medical technology with cost-effectiveness evidence and hence to assess the potential aggregate health gains from including it in decision-making.

2. HOW CONSISTENT IS MEDICARE COVERAGE POLICY FOR MEDICAL TECHNOLOGY WITH COST-EFFECTIVENESS EVIDENCE?

Coverage determinations for medical technology in Medicare are made predominantly via two mechanisms, through Medicare Administrative Contractors, and through NCDs. This research centred on NCDs as these tend to focus on technologies deemed to be particularly controversial, associated with uncertainty and inconsistency among Medicare Administrative Contractors, or projected to have a major impact on Medicare beneficiaries (Box 2) (CMS, 2010).

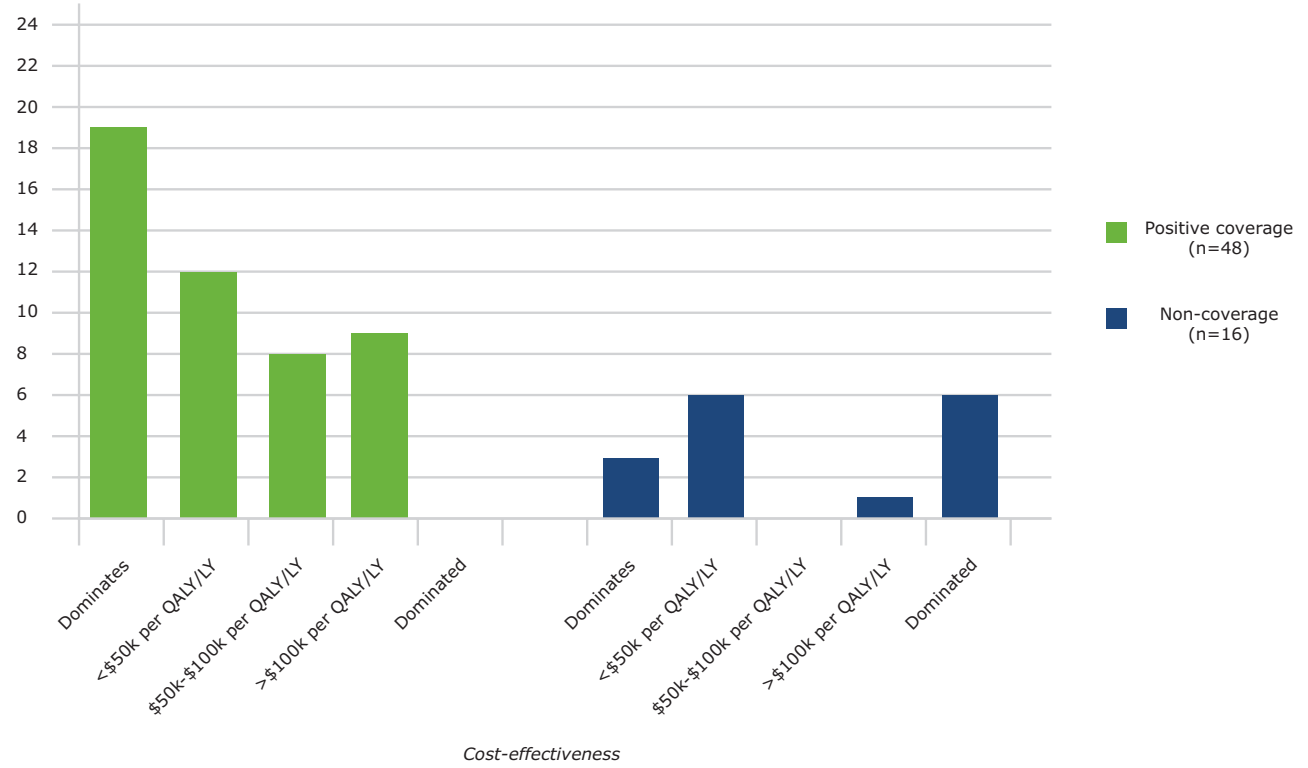
Since Medicare's inception in 1965, coverage policy has been guided by legislation mandating the programme's reimbursed items and services that are, 'reasonable and necessary for the diagnosis and treatment of an illness or injury' (Social Security Administriation, 1965). However, the 'reasonable and necessary' language is unclear, with CMS giving little guidance regarding how they interpret it (Neumann and Chambers, 2012). Research has shown that CMS does not cover all FDA approved technologies in Medicare (Chambers, May, and Neumann, 2013). While the majority of medical technologies subject to NCDs are covered in some way, access is often restricted to a narrower patient population than the approved FDA label, to patients suffering from the most severe disease and/or who have failed alternative therapeutic approaches. The objective of the first component of the case study was to evaluate the consistency of Medicare coverage policy with cost-effectiveness evidence, i.e. to evaluate if there is a difference between the cost-effectiveness of covered interventions and those not covered.

2.1 Are Medicare national coverage determinations consistent with cost-effectiveness evidence?

An NCD often includes multiple coverage decisions, with multiple technologies or indications addressed in a single decision memo, the document CMS makes publicly available to communicate the coverage policy. In this research, we considered each coverage determination separately and performed a literature search using the PubMed database, Tufts Medical Center CEA Registry, the Health Economic Evaluations Database (HEED) and the NHS Economic Evaluation Database (NHS EED) to identify relevant cost-effectiveness estimates. We included studies reporting cost-per-QALY gained or cost-per-life-year gained ratios. We also included studies reporting clinical outcomes measured in disease-specific units, such as reduction in blood pressure or decrease in ulcer surface area, when the intervention was dominant, i.e. more effective and less expensive than its comparator, or dominated, i.e. less effective and more expensive than its comparator. We included studies performed in a US setting when available; when unavailable, we included studies performed in a setting of another country by converting the incremental cost-effectiveness ratios (ICERs) into US dollars using the purchasing price parity (PPP), and inflating/deflating the value using the health care component of the US consumer price index (CPI).

Cost-effectiveness information was available for 64 coverage determinations; 48 positive coverage determinations and 16 non-coverage determinations (Appendix Tables 1 and 2). Twenty-two interventions were estimated to be dominant, six to be dominated, with the remainder associated with a positive ICER, i.e. incremental health gains were achieved at a positive cost (Figure 1). Forty-eight (70%) cost-effectiveness studies were performed in a US setting. We found that covered interventions tended to be more cost-effective than those not covered ($p<0.05$). However, a number of interventions were associated with ICERs notably higher than the established US benchmark of cost-effectiveness of $50,000 per QALY gained (Gold, Siegel, Russel and Weinstein, 1996; Hirth, Chernew, Miller, Fendrick and Weissert, 2000). Nine were associated with an ICER greater than $100,000 per QALY/LY, including six with an ICER greater than $250,000 per QALY/LY. Ventricular assist devices for destination therapy in patients suffering from heart failure were associated with the highest ICER, approximately $850,000 per QALY gained. Further details regarding this research can be found in Chambers, Neumann and Buxton (2010).

Figure 1. Cost-effectiveness of interventions included in CMS national coverage determinations



2.2 Is cost-effectiveness is an independent predictor of national coverage determinations?

The next step in the case study was to examine the consistency of NCDs with cost-effectiveness evidence when controlling for other relevant decision-making factors (Chambers, Morris, Neumann and Buxton, 2012). We relied on the Tufts Medical Center Medicare National Coverage Determinations Database – a database of NCDs including, among other things, information regarding CMS's evidence review – and supplemented it with the cost-effectiveness evidence outlined above. The dataset included 195 individual coverage determinations and the following variables: quality of evidence, alternative intervention, cost-effectiveness, type of intervention, coverage requestor and date (Appendix Table 3). Quality of evidence was a categorical variable describing the strength of the supporting clinical evidence as: good/fair; poor; or insufficient. Classification was based on an independent review of each decision memo using a scale adapted from the United States Preventive Services Task Force (USPSTF) guidelines by two trained Tufts Medical Center researchers (USPSTF, 2008). Alternative intervention was a dichotomous variable capturing whether an alternative intervention was available for the same indication (yes/no). Cost-effectiveness was a categorical variable developed using the data collected for the research described above with the following categories: no available estimate; dominates; ICER <$50,000/ QALY; and, ICER >$50,000/QALY, including dominated interventions. Cost-effectiveness included only studies available at the time of the NCD. Type of intervention was a categorical variable with the following categories: treatment; diagnostic test; or other (including health education, and mobility assistive equipment). Coverage requestor was a categorical variable with the following categories: manufacturer requested; internally generated (CMS initiated NCD); or other (medical or professional societies and organisations, patient groups, etc.). Date was a categorical

variable categorising the time-period in which each decision was made: 1999 to 2001; 2002 to 2003; 2004 to 2005; 2006 to 2007.

We used multivariate logistic regression to evaluate the data, regressing the coverage decision (positive/non-coverage) against the independent variables. In the primary analysis, the model was restricted to include only variables identified as statistically significant in univariate analyses, i.e. Quality of evidence, Alternative intervention, Cost-effectiveness and Date (Table 1).

The analysis suggests that the quality of the supporting clinical evidence, the availability of alternative interventions, the availability of cost-effectiveness evidence and the date of the decision influence the likelihood of a positive coverage decision:

- Interventions associated with good quality supporting evidence were six times more likely to be covered compared to those associated with insufficient evidence (approximately twice as likely when considering predicted probabilities)

- Compared to interventions with no available alternative, those with an available alternative were approximately eight times less likely to be covered (approaching half as likely when considering predicted probabilities)

- Compared with interventions estimated to be dominant, those with no associated estimate of cost-effectiveness were approximately five times less likely to be covered (approximately two thirds as likely when considering predicted probabilities)

- Coverage decisions made in 2006-2007 were approximately 10 times less likely to be covered than those made in 1999-2001 (half as likely when considering predicted probabilities)

This analysis gives a unique insight into the factors that influence Medicare coverage policy. It suggests that coverage policy is evidence based, with the likelihood of coverage increased with the availability of good quality clinical evidence. When controlling for the other independent variables, an intervention with no available alternatives is many times more likely to be covered than an equivalent intervention with available alternatives, possibly giving an important insight into what CMS considers 'necessary' care. Interestingly, the findings suggest that CMS has become increasingly discriminating, with the most recent coverage determinations many times less likely to be favourable that those made in earlier years. While unclear why this is the case, it may be a consequence of the Medicare programme's worsening fiscal condition. It could also be indicative of the more prominent role clinical evidence plays in coverage policy, with CMS scrutinising the evidence base with increasing rigour when judging coverage policy.

A principal aim of this analysis was to determine if favourable cost-effectiveness evidence was associated with coverage. Findings suggest that the availability of favourable cost-effectiveness evidence plays a role and that when no cost-effectiveness estimate is available, interventions are approximately five times less likely to be covered than when the intervention was estimated to be dominant. While the categories of <$50,000 per QALY and >$50,000 per QALY were not statistically

significant, the adjusted odds ratios were less than 1, consistent with a hypothesis that a more cost-effective intervention is more likely to be covered. A more thorough description of this research is available in Chambers et al. (2012).

Table 1. Results of multivariate logistic regression

Summary statistics				
Pseudo R^2 = 0.347				
Number of observations = 195				
Area under ROC curve = 0.877				
Hosmer-Lemeshow goodness-of-fit test = 0.049				
Independent variable	**Adj. OR**	**95% CI**		**Predicted probability of coverage**
Quality of supporting clinical evidence				
Good	6.3***	2.8	14.3	0.70
Poor	1.5	0.3	6.5	0.45
Insufficient	Reference category			0.39
	Joint significance p<0.01			
Alternative intervention				
No	Reference category			0.83
Yes	0.1***	0.03	0.4	0.51
Cost-effectiveness				
No estimate	0.2***	0.03	0.5	0.48
Dominates	Reference category			0.81
ICER<$50,000 per QALY gained	0.7	0.1	5.2	0.76
ICER>$50,000 per QALY gained	0.4	0.1	2.3	0.67
	Joint significance p<0.01			
Date				
1999-2001	Reference category			0.75
2002-2003	0.3**	0.1	0.9	0.56
2004-2005	0.3*	0.1	1.3	0.58
2006-2007	0.1***	0.03	0.4	0.39
	Joint significance p<0.05			

*p<0.1, ** p<0.05, ***p<0.01: OR = Odds Ratio; CI = Confidence Interval; ROC = Receiver Operating Characteristic.

2.3 What health gains could be achieved from using cost-effectiveness evidence in Medicare?

While the above research shows that NCDs are somewhat consistent with cost-effectiveness evidence, it also shows that CMS covers a number of particularly cost-ineffective interventions in Medicare. Offering cost-ineffective interventions and not offering comparatively more cost-effective interventions means aggregate health gains could be increased by redirecting resources towards the more cost-effective care. Of course, maximising health is unlikely to be CMS's sole goal. Coverage policy is multifaceted and CMS must simultaneously account for equity concerns, societal preferences for health care and likely political factors, in decision-making. Despite this, knowledge of the maximum amount of health obtainable from available resources would be of great value to CMS and policy makers. To this end, the objective of the final aspect of the case study was to estimate the potential aggregate health gains from using cost-effectiveness evidence to reallocate Medicare expenditures between interventions subject to NCDs (Chambers, 2013).

We took a league table approach, i.e. we ranked interventions in order of their cost-effectiveness and adhered to the necessary assumptions described by Johannesson and Weinstein (1993): perfect divisibility; i.e. a partially implemented health care programme will maintain the characteristics of the entire programme; and constant returns to scale; i.e. costs and effects are proportional to the scale of implementation. Data from a number of disparate sources, in addition to the cost-effectiveness evidence used previously, were required:

- We obtained incremental cost, i.e. the net present value of future expenditures, and incremental QALY gain data from the disaggregated ICER. We adjusted incremental costs to 2007 USDs when necessary.

- We estimated intervention utilisation rates using a Medicare claims database. We used diagnostic codes (International Classification of Diseases Ninth Revision (ICD-9)) to identify beneficiaries eligible for an intervention, as defined by the parameters of the NCD. We used physician reimbursement codes (Common Procedural Terminology (CPT) codes) to estimate utilisation rates by determining the number of beneficiaries with matching relevant diagnostic and reimbursement codes. We estimated the size of the unserved eligible population, i.e. beneficiaries eligible for an intervention but that did not receive it, by determining the difference between the number of beneficiaries matching both reimbursement and diagnostic codes and those a match only with diagnostic codes. When CMS did not cover an intervention, we reviewed each NCD to identify the patient population for which the decision pertained and determined its size as the number of beneficiaries matching the pertinent diagnostic codes.

The majority of interventions were associated with cost-effectiveness studies performed in a US setting (67%) and reporting a cost-per QALY ratio (60%). On occasion interventions estimated to be dominant by a cost-effectiveness study reporting disease specific units (30%), e.g. decrease in ulcer surface area, were included. These studies contributed to estimates of cost-savings but not of aggregate QALY gains. We included cost-effectiveness studies reporting a cost per life-year gained ratio (10%) by adjusting incremental survival gain using a utility weight for Americans aged 65 to

69 years (Erickson, Wilson and Shannon, 1995). As this accounts only for years of life extended, not prior years of treatment during which morbidity may have been reduced, this approach may underestimate incremental QALY gain.

Using the league table, we reallocated existing Medicare expenditures through an iterative process. First, we disinvested in the least cost-effective intervention by reducing its utilisation by 50%. Second, with the resources generated from this disinvestment, we increased the utilisation of the most cost-effective intervention by decreasing the size of the unserved eligible population by up to 50%. We repeated steps one and two, i.e. disinvesting in the next least cost-effective intervention and investing in the next most cost-effective intervention, until no further reallocation of expenditures was possible and there was no net change in expenditure. We used a 50% change in utilisation as we assumed it infeasible in practice to shift all beneficiaries from one intervention to another. We repeated the analysis using a 10% and 90% adjustment to illustrate the potential range of aggregate health gains.

This analysis required a number of additional assumptions. First, all beneficiaries meeting the parameters of the NCD received either the intervention or the comparator included in the cost-effectiveness analysis. Second, the net present value of the costs (including downstream costs) associated with an intervention was used, and for interventions with high upfront costs, we assumed resources were available for the necessary initial investment.

Required information was available for 36 interventions, 29 of which were covered, and seven not covered. Prior to reallocation, 470,000 beneficiaries received the most effective intervention included in the cost-effectiveness analysis, at a cost of approximately $8 billion. Following reallocation, an estimated 11.1 million additional beneficiaries received the most effective intervention, corresponding to aggregate health gains of 1.8 million QALYs, approximately 0.17 QALYs per affected beneficiary (Table 2). When including only interventions with an associated estimate of incremental QALY gain, aggregate health gains were reduced but remained substantial (1.6 million QALYs).

Table 2. Reallocation of Medicare Expenditures

Reallocation	Additional beneficiaries receiving most effective intervention (millions) (50% [10-90%])	QALY gain (millions) (50% [10-90%])
All interventions – irrespective of unit of health outcome	11.1 (2.2 – 20.0)	1.8 (0.37 – 3.4)
Including only interventions with QALY data	6.1 (1.2 – 11.0)	1.6 (0.32 – 2.9)

Given the data limitations, this aspect of the case study should be considered illustrative, rather than a precise accounting exercise. As CMS does not perform cost-effectiveness analyses, nor requires their submission, there was an expected lack of consistency with respect to perspective, costing, setting, etc. of included studies. While recommendations for conducting cost-effectiveness analyses in the US exist, evidence suggests they are followed inconsistently (Phillips and Chen, 2002). The use of ICD-9 diagnostic codes was a necessary but crude approach. In addition to the inherent coding inaccuracies present in all datasets, ICD-9 diagnostic codes do not sufficiently capture all patient characteristics and other factors that inform patient management, e.g. clinical opinion and patient preference (O'Malley et al., 2005). While for some indications diagnostic codes accurately identified eligible beneficiaries, e.g. foot care for diabetic patients, on others they were less precise, e.g. deep brain stimulation for Parkinson's disease patients for whom pharmaceutical management is no longer effective. A further limitation was that we did not account for the feasibility of implementing changes in patient care. It would likely be challenging to change a beneficiary's treatment if it is deeply entrenched in clinical practice. While we accounted for this by adjusting utilisation by 50%, as opposed to a reduction to 0% or an increase to 100%, the change was arbitrary.

Despite these limitations, and the need to integrate data from various sources, findings are highly illustrative. The study suggests that using cost-effectiveness evidence to reallocate expenditures has potential to lead to substantial health gains. A full description of this research is available in Chambers et al. (2013).

3. DISCUSSION

Estimates that 30% of US health care spending is wasteful, coupled with unsustainable spending growth, highlight the urgent need to increase health care efficiency (Bentley, Effros, Palar and Keeler, 2008; Smith et al., 2013; Keehan et al., 2012). The US's greater reliance on medical technology and high tech services than other countries, a major driver of rising health care costs, exacerbates the situation (Kaiser Family Foundation, 2012; Fuchs, 2013). Across the health care system, payers have chosen to use cost-effectiveness analysis in only a marginal way and by doing so have largely avoided the difficult cost-benefit trade-offs illuminated by such evidence. Avoidance of these trade-offs may have contributed to the US health care system's current fiscal predicament.

3.1 Uneven use of cost-effectiveness evidence throughout the US health care system

Despite American exceptionalism, and opposition from some quarters, some have called for the formal inclusion of cost-effectiveness evidence in US decision making (Neumann et al., 2008; Neumann, Rosen, and Weinstein, 2005; Gold, Sofaer, and Siegelberg, 2007; Bryan, Sofaer, Siegelberg and Gold, 2009; Wilensky, 2008). Indeed, there is recognition of the value of cost-effectiveness evidence across parts of US health care. A study of US decision makers, including

regulators, and private and public insurers, showed a degree of support for cost-effectiveness evidence as an input into coverage decisions for medical technology (Bryan et al., 2009). However, the study identified important obstacles, including litigation fears, concerns of the biased nature of manufacturer funded studies and the relevance of cost-effectiveness evidence to decision makers. Notably, approximately 40% of decision makers stated their unease with the concept of rationing. Current use of cost-effectiveness across US health care mirrors these findings, with varied and inconsistent application across private and public payers.

The guidelines provided by WellPoint and the AMCP indicate that at least some private payers have the necessary sophistication to evaluate economic evidence, and have a preference for how cost-effectiveness studies should be performed and reported (WellPoint, 2008; AMCP, 2010). However, it may be that the application of value-based insurance design to drug formularies, as illustrated by Premera Blue Cross, will provide a path for cost-effectiveness evidence to diffuse more broadly into the private payer market. Cost-effectiveness evidence can be used in value-based insurance design to lower patient cost-sharing for high value services, and in so doing to encourage patients to participate in their health care choices and use cost-effective care. In this way, rather than used as a tool to deny patients access to cost-ineffective care, cost-effectiveness evidence is used in a more palatable way, to promote use of high value care without affecting patient choice.

A number of public payers, including the Department of Defense Pharmacoeconomic Center and the Department of Veteran Affairs Health Economic Resource Center, use cost-effectiveness evidence, with the state of Washington's health technology assessment programme being the most recent to incorporate it into their evaluation of medical technology. However, it remains effectively excluded from CMS's evidence review in Medicare NCDs for treatments and used in a limited manner for preventive care.

The Medicare case study showed that while coverage policy appears broadly consistent with the clinical evidence base, CMS cover a number of cost-ineffective technologies. Despite the data limitations, the case study also illustrated that using cost-effectiveness evidence has the potential to lead to substantial aggregate health gains. The case study's findings suggest that by excluding cost-effectiveness from their deliberations, CMS is missing opportunities to increase programme efficiency.

Even if society's reluctance to accept limits could be overcome, and decision makers chose to more fully incorporate cost-effectiveness into coverage policy, a number of legislative and institutional obstacles remain.

3.2 Legislative and institutional obstacles facing cost-effectiveness

A telling case is the Patient-Centered Outcomes Research Institute, an institute established to evaluate the comparative effectiveness of health care interventions, to disseminate the information to patients and health care decision makers to promote informed health care decisions and improve health care delivery and outcomes. (PCORI, 2013). Notably, the ACA legislation imposed restrictions regarding the consideration of cost-effectiveness in its research:

> The Patient-Centered Outcomes Research Institute . . . shall not develop or employ a dollars per quality adjusted life year (or similar measure that discounts the value of a life because of an individual's disability) as a threshold to establish what type of health care is cost effective or recommended. The Secretary shall not utilize such an adjusted life year (or such a similar measure) as a threshold to determine coverage, reimbursement or incentive programs under title XVIII. (Social Security Administration, 2010)

While not prohibiting cost-effectiveness evidence outright, rather the use of a cost-per-QALY threshold, leading academics have voiced concerns that the legislation will have a 'chilling effect' on its role in US health care (Neumann and Weinstein, 2010). While a focus on comparative clinical effectiveness is understandable, and arguably a prudent starting point to identify ineffective or low-value care, excluding costs limits the institute's ability to promote economically efficient use of technology.

The 2011 NCD for sipuleucel-T (Provenge®), an expensive vaccine-based treatment indicated for advanced prostate cancer, illustrated the extent of the challenge CMS faces when addressing new expensive technology (Box 3). CMS opened a national coverage analysis in response to concerns as to whether and how regional Medicare administrative contractors would pay for the treatment. Ultimately, after much debate and stakeholder comment, CMS covered sipuleucel-T in accordance with the approved FDA indication (Chambers and Neumann, 2011; CMS, 2011). This NCD showed that without authority to negotiate a therapy's price, and with cost-effectiveness evidence excluded its review, CMS's only option when addressing costly technology is to closely scrutinise the clinical evidence base and to emphasise outcomes and subgroups (Neumann and Chambers, 2012). The sipuleucel-T case shows that without the ability to consider cost-effectiveness evidence, CMS has few options but to cover interventions that offer marginal incremental health benefits, irrespective of their cost and budget impact.

The case of bevacizumab (Avastin®) for breast cancer further illustrates the challenges faced by CMS (Box 4). Despite the FDA judging the treatment not to be safe and effective for metastatic breast cancer, CMS's reliance on four specified compendia – sources of medically accepted off-label uses of anticancer treatments – means that CMS continues to pay for bevacizumab to treat breast cancer (FDA, 2013). The result is that Medicare beneficiaries have access to an intervention with uncertain clinical benefits, despite its high cost.

While marginal use cost-effectiveness evidence directly affects the use and availability of technology in US health care, it may also indirectly impact other countries and global pharmaceutical R&D.

3.3 Ex-US consequences

Patients in the US typically have more rapid and comprehensive access to pharmaceuticals than patients in other countries (Mason, Drummond, Ramsey, Campbell and Raisch, 2010). However, US pharmaceutical prices are higher than those in countries where prices are regulated and where cost-effectiveness analysis plays a role in coverage and reimbursement policy (Kanavos, Ferrario, Vandoros and Anderson, 2013; Cohen, Malins and Shahpurwala, 2013). As high US pharmaceutical prices account for a large proportion of pharmaceutical companies' profits, it is argued that the US is subsidising innovation in other countries, although this is debated in the literature (Hopkins, 2003; PhRMA, 2009; Keyhani, Wang, Hebert, Carpenter and Anderson, 2010).

Given its size and profitability, the US pharmaceutical market likely has a major influence on global pharmaceutical R&D investment. Cost-effectiveness evidence's limited role in the US may in turn influence R&D investment decisions. The potential consequences of using cost-effectiveness analysis to guide coverage and reimbursement decisions on future medical technology innovation have been widely debated (Vernon, Goldberg and Golec, 2009; Jena and Philipson, 2007; Jena and Philipson, 2008; Innovation, Bioscience and Growth Team, 2009). One consequence may be that if the cost-effectiveness of new pharmaceuticals had a fundamental role in their coverage and reimbursement, then there would be an incentive for industry to direct R&D resources toward indications with the largest unmet health need, i.e. for which largest incremental health gains were possible, as a higher price could be sought while maintaining reasonable cost-effectiveness. In contrast, if cost-effectiveness were not a factor, industry may focus on indications for which new treatments are likely most profitable, irrespective of their unmet health need. The result may be that pharmaceutical companies focused on the US market do not necessarily invest in R&D for indications for which the greatest unmet health need exists.

If an assessment of value became a requirement before a new medical technology could be marketed in the US, lessons could be learned from approaches taken elsewhere.

3.4 Lessons from abroad

The UK, Australia, Canada and Sweden are among countries with health technology assessment bodies that systematically weigh new technologies' costs and benefits before they are available in the health care system (Lopert and Elshaug, 2013; Neumann et al., 2010). In these countries cost-effectiveness evidence has played a longstanding and fundamental role. However, it may be the experiences of Germany and France, from which the US could learn most. Much like the US, Germany and France principally relied upon an assessment of safety, efficacy and quality to inform coverage of medical technology. However, both countries have recently started to evaluate the costs and benefits of medical technology in their health technology assessment programmes. In 2007 the German Institute for Quality and Efficiency in Health Care's (IQWiG) responsibilities were extended to weighing the costs and benefits of pharmaceuticals (IQWiG, 2013). The Institute's analysis informs whether a new technology represents good value for money by estimating the

'going rate' for the additional cost per health benefit (Caro et al., 2010b). In 2008, the mission of the Haute Autorité de Santé (HAS), or French National Authority for Health, was expanded to 'recommendations and medico-economic opinions on the most effective strategies of care, prescription, and disease management' (Rochaix and Xerri, 2009). Economic evaluations help illustrate the opportunity costs associated with reimbursement decisions, with the intention of promoting efficient use of medical technology. It is notable that in Germany and France, the incorporation of economic evaluation into health technology assessment has not fundamentally changed coverage policy and decision-making remains grounded in the clinical evidence base.

While there is no universally accepted standard for evaluating new technologies' costs and benefits, with IQWiG's methods subject to particular scrutiny, in Europe a broad consensus has emerged regarding the importance of including economic evaluation in health technology assessment (Sculpher and Claxton, 2010; Brouwer and Rutten, 2010; Caro et al., 2010a). The US has yet to move in this direction; rather the emphasis is on payment reform to address rising health care costs and inefficient health care spending.

3.5 Payment reform: An alternative approach to increase health care efficiency

To date, alternative approaches to cost-effectiveness for arresting growth in US health care spending and increasing health care efficiency have been preferred. Legislation has moved Medicare and private payers towards prospective payment systems or global capitation arrangements such as bundled payments and Accountable Care Organisations (ACOs). While these approaches do not directly affect coverage of medical technology, they provide incentives for more efficient use of it.

In a bundled payment, the provider receives a single payment for delivering an episode of care. If the cost of providing care is less than the bundled payment, the provider profits; if the cost of providing care exceeds the bundled payment, the provider must incur the additional cost. Bundled payments are appealing because as both payers and providers share financial risk, they encourage delivery of cost-effective care. An example is the recently implemented Medicare expanded end-stage renal disease bundled payment, which extended the existing payment for dialysis services to include, among other things, erythropoietin stimulating agents, a particularly costly aspect of dialysis care (Chambers, Weiner, Bliss and Neumann, 2013; Swaminathan, Mor, Mehrotra and Trivedi, 2012). Reports estimate that following the policy's implementation, use of erythropoietin stimulating agents dosing was reduced by approximately 15–20% (Collins, 2012; Pisoni, Fuller, Bieber, Gillespie and Robinson, 2012; Gilbertson, Collins and Foley, 2012).

A key part of US health care reform has been to promote and establish ACOs (The Patient Protection and Affordable Care Act (PL 111-148. 2010)). Accountable care organisations are more comprehensive than bundled payments and are composed of networks of physicians, hospitals and other health care providers. The ACO receives a single payment for managing the care for a defined group of patients and thus shares some responsibility and financial risk with the payer (Miller, 2009; Chambers et

al, 2011; Woolf and Aron, 2013). As with bundled payments, the hope is that as the ACO incurs some financial risk, health care delivery will be more efficient. For both bundled payments and ACOs, an important concern is that in order to make a profit, providers will skimp on care and/or avoid treating complex and expensive-to-treat patients. Therefore, these payment policies typically attempt to account for patient health status through some form of risk adjustment and incorporate a bonus payment or penalty contingent upon the quality of care provided (Averill, Goldfield, Hughes, Eisenhandler and Vertrees, 2009; Miller, 2009).

4. CONCLUSIONS

Health care systems across the globe face the challenge of providing access to expensive new medical technology. This challenge is keenly felt in the US, where despite health care spending being massively higher than in other developed countries, the health care system performs comparatively poorly. Despite this, the US remains an outlier with respect to the use of cost-effectiveness evidence to evaluate medical technology, with various obstacles having prevented its broader diffusion into US health care. The Medicare case study suggests potential benefits of using cost-effectiveness evidence and that aggregate health gains may be possible from using it to inform the coverage of medical technology.

Time will tell if payment reform and comparative effectiveness evidence will control health care costs and prove sufficient to improve health care system efficiency. Nevertheless, with the US health care system facing the ever increasing challenge of absorbing the high cost of new innovations, by excluding cost-effectiveness evidence from coverage deliberations, a valuable tool for encouraging efficient use of technology is being overlooked.

BOXES

Box 1: The U.S. Preventive Services Task Force (USPSTF) breast cancer screening recommendations

The U.S. Preventive Services Task Force (USPSTF) is an independent panel of experts in evidence-based medicine and prevention charged with conducting reviews of a range of clinical preventive medical interventions – including screening tests, counselling and preventive medications – and providing recommendations. The USPSTF reviews the available evidence and evaluates the potential benefits and harms of each service based on age, sex and risk factors for disease (USPSTF, 2013). In November 2009, the U.S. Preventive Services Task Force (USPSTF) published updated breast cancer screening recommendations. The update recommended that women wait until age 50 before receiving their first mammogram, a change from the existing recommendation of age 40, and that screening frequency should be every two years, not the one to two years of the previous recommendation (Calonge et al., 2009). Following publication, there was immediate opposition from various aspects of the medical community, patient advocacy groups and professional societies, e.g. the American College of Radiology and the American Cancer Society. While the USPSTF do not evaluate the cost-effectiveness of preventive interventions, it was asserted that the task force's recommendations were a step towards health care rationing.

Box 2: National Coverage Determinations

Formal coverage determinations for health care interventions and services are made by the Centers for Medicare and Medicaid Services (CMS) at either the local or the national level. Thirteen independent regional Medicare administrative contractors make local coverage policies, or local coverage determinations (LCDs), the absence of a national coverage policy, which represent the majority of Medicare coverage policies. CMS makes approximately 10-15 national coverage determinations (NCDs) each year which are reserved for interventions deemed particularly controversial or projected to have a major impact on the Medicare programme. CMS makes NCDs publicly available by posting decision memoranda on its website. Decision memoranda present a brief clinical background to the disease, review the history of Medicare coverage for the intervention, review and evaluate scientific and clinical literature relevant to the decision and provide reasoning for the coverage decision. National coverage determinations have been used to evaluate a range of interventions, including surgeries, medical devices and outpatient drugs, i.e. drugs administered by a physician. Coverage for other prescription drugs in Medicare is through a separate process, Medicare Part D.

Box 3: Sipuleucel-T (Provenge®) for advanced prostate cancer

In April 2010, the FDA approved sipuleucel-T (Provenge®) for the treatment of asymptomatic or minimally symptomatic, metastatic, castration-resistant (hormone refractory) prostate cancer. Sipuleucel-T is a novel cellular immunotherapy and the pivotal clinical trials estimated survival gains of 4.1 months compared to placebo. The treatment is notable for its high cost, $93,000 for a course of three treatments, with a recent cost-effectiveness study estimating its cost-effectiveness to be $283,000 per QALY gained compared to standard treatment (Holko and Kawalec, 2013).

In an unexpected move, and in response to the challenge of how to pay for an intervention that could have a huge potential impact on programme cost, in June 2010 the Centers for Medicare and Medicaid Services (CMS) opened a national coverage analysis for sipuleucel-T. Ultimately, after much debate and comment from stakeholders, CMS covered sipuleucel-T in accordance with the approved FDA labelled indication (Chambers and Neumann, 2011; CMS, 2011). This NCD serves as a useful case study of CMS's limited flexibility regarding coverage. Without the authority to negotiate a technology's price or to consider cost-effectiveness evidence, CMS's only option is to closely scrutinise the clinical evidence base. The sipuleucel-T case shows that without the authority to consider cost-effectiveness evidence, CMS has little alternative but to cover interventions that offer marginal incremental health benefits, irrespective of their cost.

Box 4: Coverage of cancer treatments for off-label indications

Patients in the US have better access to cancer treatments than patients in Europe (Cohen et al., 2013). US authorities have found restricting coverage for cancer therapies to be challenging, even when supporting clinical evidence is questionable (Neumann, Bliss and Chambers, 2012). In addition to covering cancer treatments for on-label indications, Medicare pays for off-label uses of cancer drugs listed in one of four specified compendia (CMS, 2013a). Covering cancer therapies so broadly, even when there is limited supporting clinical evidence, presents an obvious challenge for payers (Abernethy et al., 2009). An illustrative example is the off-label coverage of bevacizumab (Avastin®) for breast cancer. In November 2011, the FDA recommended that because the clinical evidence showed the treatment not to be safe and effective, Avastin should no longer be used to treat breast cancer (FDA, 2013). Despite the prohibitive cost of Avastin – approximately $88,000 for treating metastatic breast cancer – CMS has continued to pay for the treatment as its use for metastatic breast cancer continues to be listed in the approved anticancer compendia.

APPENDIX

Table 1. Positive coverage decisions associated with an estimate of cost-effectiveness

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
1	Cryosurgery Ablation for Prostate - Primary treatment for clinically localised prostate cancer. (StageT1-T3)	1999	Dominant	Other	USA	Benoit RM et al. (1998)
2	Breast Biopsy - Stereotactic core needle image guidance	1999	Dominant	Other	USA	Lee et al. (1997)
3	Breast Biopsy - Ultrasound image guidance	1999	Dominant	Other	USA	Liberman L et al. (1998)
4	Diabetic Peripheral Neuropathy with Loss of Protective Sensation - diabetic patients who meet specified conditions	2001	Dominant	QALY	Sweden	Ragnarson Tennvall G et al. (2001)
5	Positron Emission Tomography - Lung Cancer (non-small cell)	2000	Dominant	Other	USA	Valk PE et al. (1996)
6	Positron Emission Tomography - Colorectal Cancer	2000	Dominant	Other	USA	Valk PE et al. (1996)
7	Positron Emission Tomography - Melanoma	2000	Dominant	Other	USA	Valk PE et al. (1996)

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
8	Ambulatory blood pressure monitoring - Use in patients with high blood pressure who meet specified criteria	2001	Dominant	Other	UK	Aitken (1996)
9	Prothrombin Time (INR) Monitor for Home Anticoagulation Management - Patients with mechanical heart valves that meet specific criteria	2001	Dominant	Other	Germany	Völler H et al. (2001)
10	Cardiac rehabilitation programs - Acute Myocardial Infarction	2006	Dominant	QALY	USA	Yu C et al. (2004)
11	Cardiac rehabilitation programs - Percutaneous Transluminal Coronary Angioplasty	2006	Dominant	QALY	USA	Yu C et al. (2004)
12	Positron Emission Tomography (FDG) for Breast Cancer - Detection of Locoregional Recurrence or Distant Metastasis/ Recurrence (Staging and Restaging)	2002	Dominant	Other	Canada	Sloka JS et al. (2005)
13	Positron Emission Tomography (FDG) for Myocardial Viability - PET as a primary or initial diagnostic study	2002	Dominant	Other	Australia	Miles KA (2001)
14	Intravenous Immune Globulin for Autoimmune Mucocutaneous Blistering Diseases - Pemphigus Vulgaris	2002	Dominant	Other	USA	Daoud YJ (2006)

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
15	Intravenous Immune Globulin for Autoimmune Mucocutaneous Blistering Diseases - Bullous Pemphigoid	2002	Dominant	Other	USA	Daoud YJ (2006)
16	Intravenous Immune Globulin for Autoimmune Mucocutaneous Blistering Diseases - Mucous Membrane Pemphigoid	2002	Dominant	Other	USA	Daoud YJ (2006)
17	Magnetic Resonance Angiography of the Abdomen and Pelvis - Imaging the renal arteries and the aortoiliac arteries when using MRA is expected to avoid obtaining contrast angiography	2003	Dominant	Other	USA	Levy MM et al. (1998)
18	Positron Emission Tomography (N-13 Ammonia) for Myocardial Perfusion - Diagnosis of myocardial perfusion	2003	Dominant	Other	Switzerland	Siegrist PT et al. (2007)
19	Smoking and Tobacco Use Cessation Counselling	2005	Dominant	Other	USA	CMS Decision Memo (CAG-00241N)
20	Screening Immunoassay Fecal-Occult Blood Test (Hemoccult II FOBT)	2003	$1,072	Life years	USA	Report to the Agency for Health care Research and Quality (2003)
21	Positron Emission Tomography - Head and Neck Cancers	2000	$2,395	QALY	USA	Hollenbeak CS et al. (2001)
22	Continuous Positive Airway Pressure (CPAP) Therapy for Obstructive Sleep Apnoea (OSA).	2001	$3,079	QALY	USA	Ayas NT et al, (2006)

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
23	Hyperbaric Oxygen Therapy - Diabetic Wounds of the Lower Extremities that fit specified criteria	2002	$5,409	QALY	USA	Guo S et al. (2003)
24	Cochlear implantation - Post lingually hearing impaired patients	2005	$10,729	QALY	USA	Francis HW et al. (2002)
25	Cochlear implantation - Pre lingually hearing-impaired patients	2005	$10,953	QALY	USA	Francis HW et al. (2002)
26	Bariatric Surgery for the Treatment of Morbid Obesity - Open Roux-en-Y gastric bypass (RYGBP)	2006	$12,733	QALY	UK	Clegg A et al. (2003)
27	Bariatric Surgery for the Treatment of Morbid Obesity - Laparoscopic adjustable gastric banding (LAGB)	2006	$17,264	QALY	UK	Clegg A et al. (2003)
28	Erythropoiesis Stimulating Agents (ESAs) for non-renal disease indications - Treatment of chemotherapy induced anaemia for patients who meet specified criteria	2007	$18,713	QALY	UK	Martin SC et al. (2003)
29	Screening Immunoassay Fecal-Occult Blood Test (iFOBT)	2003	$21,001	Life years	USA	Report to the Agency for Health care Research and Quality (2003)
30	Autologous Stem Cell Transplantation (AuSCT) for Multiple Myeloma - Treatment of multiple myeloma for patients who meet certain conditions	2000	$27,687	Life years	USA	Trippoli S et al. (1998)

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
31	Implantable Cardioverter Defibrillators (ICDs) - Documented sustained ventricular tachyarrhythmia	2003	$36,396	Life years	USA	Mushlin AI et al. (1998)
32	Deep Brain Stimulation for Parkinson's Disease (PD) - PD patients that meet specified criteria	2003	$55,826	QALY	USA	Tomaszewski et al. (2001)
33	Microvolt T-wave Alternans - diagnostic testing for patients at risk of sudden cardiac death when the spectral analytic method is used	2007	$55,126	QALY	USA	Chan PS et al. (2006)
34	Positron Emission Tomography - Esophageal Cancer	2000	$60,544	QALY	USA	Wallace MB et al. (2002)
35	Implantable Defibrillators 2 - NIDCM, documented prior MI, Class II and III heart failure	2005	$70,200	QALY	USA	Sanders G et al. (2005)
36	Implantable Cardioverter Defibrillators (ICDs) - Documented familial or inherited conditions with a high risk of ventricular tachyarrhythmia	2003	$84,439	Life years	USA	Larsen G et al, (2002)
37	Pancreas Transplants - Patients that meet the specified criteria (type 1 diabetes etc.)	2007	$90,159	QALY	USA	Kiberd BA et al. (2000)
38	Ultrasound Stimulation for Nonunion Fracture Healing - Tibial	2005	$94,848	QALY	Australia	MSAC application 1030 2001)

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
39	Aprepitant for Chemotherapy-Induced Emesis - For use following specified chemotherapies	2005	$97,429	QALY	USA	Moore S et al. (2007)
40	Liver transplantation in patients suffering from hepatitis B	1999	$145,749	QALY	USA	Dan YY et al. (2006)
41	Ocular Photodynamic Therapy with Verteporfin for Macular Degeneration - Predominately classic subfoveal CNV lesions	2004	$172,770	QALY	UK	Meads et al. (2002)
42	Lung Volume Reduction Surgery - Severe upper lobe emphysema	2003	$175,790	QALY	USA	Ramsey et al. (2003)
43	Transmyocardial revascularisation for Severe Angina - Patients with severe angina (stable or unstable), refractory to standard medical therapy.	1998	$337,568	QALY	UK	Campbell HE et al. (2001)
44	Lung Volume Reduction Surgery - Non high risk patients suffering from non-upper lobe emphysema with low exercise capacity	2003	$343,259	QALY	USA	Ramsey et al. (2003)
45	Ultrasound Stimulation for Nonunion Fracture Healing - Radius	2005	$446,384	QALY	Australia	MSAC application 1030 (2001)
46	Ultrasound Stimulation for Nonunion Fracture Healing - Scaphoid	2005	$570,379	QALY	Australia	MSAC application 1030 (2001)

No.	Technology - Coverage decision	Year	ICER (US$)	Outcome measure*	Study country	Reference
47	Insulin Infusion Pump - Type 1 diabetic patients	1999	$511,683	QALY	UK	Colquitt et al. (2004)
48	Ventricular Assist Devices as Destination Therapy - Chronic end-stage heart failure patients that meet specified criteria	2003	$834,924	QALY	USA	Samson D (2004)

* QALY = Quality Adjusted Life Year; Life years = Life years gained; Other = Study-specific clinical outcome.

Table 2. Non-coverage decisions associated with an estimate of cost-effectiveness

No.	Technology - Coverage decision	Year	ICER	Outcome measure*	Study country	Reference
1	Positron Emission Tomography (FDG) for Breast Cancer - Initial Staging of Axillary Lymph Nodes	2002	Dominant	Other	Australia	Miles KA (2001)
2	Warm-Up Wound Therapy aka Noncontact Normothermic Wound Therapy (NNWT)	2002	Dominant	QALY	USA	Macario A et al. (2002)
3	Positron Emission Tomography (FDG) for Brain, Cervical, Ovarian, Pancreatic, Small Cell Lung, and Testicular Cancers - Ovarian Cancer	2005	Dominant	Other	USA	Smith GT et al. (1999)
4	External Counterpulsation (ECP) Therapy	2006	$3,126	QALY	USA	Varricchione (2006)
5	Electrical Bioimpedance for Cardiac Output Monitoring	2006	$6,137	QALY	USA	CMS Decision memo – (CAG-00001R2)
6	Bariatric Surgery for the Treatment of Morbid Obesity - BMI of 50 and no comorbidities	2006	$11,524	QALY	USA	Craig BM et al. (2002)
7	Lumbar Artificial Disc Replacement	2007	$16,957	QALY	Australia	MSAC application 1090 (2000)
8	Acupuncture - Osteoarthritis	2003	$17,249	QALY	Germany	Reinhold et al. (2007)

No.	Technology - Coverage decision	Year	ICER	Outcome measure*	Study country	Reference
9	Bariatric Surgery for the Treatment of Morbid Obesity - Stated treatments indicated for obesity alone BMI of 40	2006	$31,861	QALY	USA	Craig BM et al. (2002)
10	Diabetic Peripheral Neuropathy with Loss of Protective Sensation - Coverage for diabetics without loss of protective sensation)	2001	$187,472	QALY	Austria	Rauner MS et al. (2005)
11	Percutaneous Transluminal Angioplasty (PTA) of the Carotid Artery Concurrent with Stenting	2001	Dominated	Other	USA	Jordan WD et al. (1998)
12	Lung Volume Reduction Surgery - High-risk patients suffering from severe emphysema	2003	Dominated	QALY	USA	Ramsey et al. (2003)
13	Lung Volume Reduction Surgery - Non high risk patients suffering from non-upper lobe emphysema with low exercise capacity	2003	Dominated	QALY	USA	Ramsey et al. (2003)
14	Implantable Cardioverter Defibrillators (ICDs) - Acute Myocardial Infarction	2003	Dominated	QALY	USA	Sanders G et al. (2005)
15	Implantable Cardioverter Defibrillators (ICDs) - Patients who have undergone a coronary artery bypass graft	2003	Dominated	QALY	USA	Sanders G et al. (2005)
16	Positron Emission Tomography (FDG) - For Alzheimer's Disease/Dementia	2003	Dominated	QALY	USA	Matchar DB et al. (2001)

* QALY = Quality Adjusted Life Year; Life years = life years gained; Other = Study-specific clinical outcome.

Table 3. Variables included in the multivariate regression analysis

Variable	Description	Variable		
		Construction	Definition	% of observations*
Dependent variable				
Coverage decision	Outcome of the coverage decision.	Dichotomous variable	Positive coverage	54%
			Non-coverage decision	46%
Independent variables				
Quality of evidence	A review of the supporting clinical evidence as presented in the decision memo performed independently by two reviewers.	Categorical variable – Categorised using USPSTF guidelines (Table 2)	Good	53%
			Poor	10%
			Insufficient	37%
Alternative intervention	The availability of an alternative intervention for the same indication.	Dichotomous variable	Alternative available	83%
			No alternative available	17%
Cost-effectiveness	Estimate of cost-effectiveness for the intervention.	Categorical variable	No estimate	79%
			Dominates	8%
			ICER <$50k/QALY	6%
			ICER >$50k/QALY	8%
Type of intervention	The broad indication of the intervention.	Categorical variable	Treatment	67%
			Diagnostic test (includes staging/ screening/ monitoring)	28%
			Other (including health education, preventive care and mobility assistive equipment)	5%
Coverage requestor	The group or individual that requested coverage.	Categorical variable	Manufacturer requested	32%
			Internally generated	37%
			Other (includes medical/ professional society or organisation)	41%

Variable	Description	Variable		
		Construction	Definition	% of observations*
Date	Decisions grouped into years	Categorical variable	1999-2001	22.6%
			2002-2003	36.9%
			2004-2005	14.9%
			2006-2007	25.6%

* Percentages may not add to 100% due to rounding.

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