



Commonwealth Department of  
Health and  
Aged Care

# Technology, Health and Health Care

**Occasional Papers: Health Financing Series  
Volume 5**

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Commonwealth Department of Health and Aged Care

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# Foreword

Much of the public focus on Australia's health care system is around issues of how to best provide high quality, accessible care at a reasonable cost. That is a discussion well worth having. Yet frequently that discussion is polarised around arguments about whether the health system as a whole, or at least important components of it, are 'in crisis' or 'unsustainable'. Concerns about public hospital waiting lists and the affordability of private health insurance are two examples of this manifestation. Against that, there are also many 'good news' stories about health: exciting new medical and pharmaceutical breakthroughs, or gains in public health through successful immunisation campaigns being examples.

The fascination about health issues and the debate about priorities and approaches is understandable and necessary. At one level, birth, sickness and eventual death are aspects of life that confront all of us. We want the best for our families and more generally for society as a whole. At another level, health accounts for about 8.5 per cent of Australia's Gross Domestic Product (ie almost one in every twelve dollars). The point is that we all have a keen interest in good health and in finding ways of better achieving it.

In Australia, we have a health system that serves us well, and compares well, on many key indicators, to overseas systems. While there is room for improvement, the complexity of the system makes it difficult to agree on where improvements are needed, what trade offs we are prepared to make in order to gain these improvements, and what changes will deliver the results we seek. Hence the presence of as many, if not more, 'solutions' in the debate as there are stakeholders.

This series of papers—coming out of the Department's *Health Financing Project*—is intended to contribute to the debate by providing data and analysis that is not generally easily accessible. The papers are by no means the last word on the subject; they do not seek to cover all perspectives, for that would be too big a task. This is the fifth volume in the series and examines the role of technology in health care in Australia.

We hope that you will find the papers a useful contribution to the debate.

David Borthwick

Deputy Secretary

March 2000

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# Technology, Health and Health Care

## Introduction

Technology is a crucial ingredient of health care. Indeed, all health care consists of either human interaction, the application of technology, or, most commonly, both. Consideration of technology is important in any examination of the organisation and functioning of health care services and systems for many reasons: Technology is a major component of current health care costs and perhaps the key driver of future cost. Major regulatory frameworks and institutions exist solely to manage the introduction and use of safe, effective and efficient technology in health care. Advances in health care technology have the potential to be major sources of economic wealth as well as forces for change in the organisation of health care. The health and medical research and development sector, from which advances arise, has a high public profile in its own right. Finally, there is great community interest in technology, especially technology that has important implications for health.

Patterns of use and consumption of health care technologies are influenced by the well-known market imperfections in health care. These imperfections are driven by two principle factors: information asymmetries and third party payment systems. Information asymmetries occur when the ultimate consumers (patients) have less information than their agents (their treating doctors). Third party payment means that the ultimate consumer (patients) are not the immediate purchasers of services. Instead, in Australia, payment is usually made by third parties (government or insurers) that are remote from the decision-making process behind individual purchasing decisions. These market imperfections contribute to many of the problems of cost and regulation of medical technology described in this paper. For example, the separation of consumers, their agents and payers results in purchasing decisions being insensitive to price signals, with the potential for overconsumption.





## **Technology and Human History**

When thinking about the relationship between technology on the one hand, and health and health financing on the other, most people think of ‘high tech’, that is items of technology such as MRI scanners, biotechnology and cardiac catheter laboratories. High tech is important, and most of this paper focuses on this common view of technology and health. However, it is worthwhile to briefly take a broader view.

Technology has been impinging on human health since the origins of human kind. The development of tools, weapons for hunting, clothing, controllable fire, language, money, boats and containers for storing and carrying things are all technologies that played an important role in sustaining and advancing the spread of people around the globe. In the last five to ten thousand years, the development of the technologies of agriculture, writing, the wheel, pottery, paper, strong building materials and metals, among others, have played a crucial role in the development of civilizations. All of these seemingly fundamental technologies have also played, and continue to play, a crucial role in the health of human populations.

The explosion in the development of technology since the industrial revolution has witnessed the discovery and widespread use of steam power, electricity, glass, plastics, internal combustion engines and many other technologies. The last few hundred years have also witnessed a host of fundamental scientific discoveries that have led to the development of the advanced technologies of today. These discoveries have occurred in the areas of optics, mathematics, molecular, atomic and nuclear structure, relativity and quantum mechanics, genetics, physiology, biochemistry, anatomy, microbiology and immunology, to name a few.

It should be noted that science and technology are not the same thing: technology is tools for doing things, whereas science is a method of thinking and of examining nature that can lead to new knowledge. Science is a voracious user of technology, and frequently leads to technological advance, but is conceptually quite distinct from technology.

One of the characteristics of the discoveries of science and the advances in technology of the last few hundred years is that they are catalytic and synergistic. In other words, discoveries in one area of science lead to discoveries in other areas, technologies arising from discoveries lead to further discoveries, and technologies arising from different areas of science can be combined to form new technologies. Contemporary examples are genetic/molecular biology and information technology, where there is already a large overlap. This overlap is largely in the direction of information technology assisting the advance of molecular biology, but research is underway in the development of computers based on molecular biology. If this research realises its vision, today’s computers and mass storage devices may compare to the pocket calculator.

This paper does not attempt to provide a comprehensive coverage of all issues relevant to health technology. Instead, it attempts to examine some of the more significant issues in order to introduce the reader to the complexities of the area. It presents, where available, illustrative empirical information, examples and commentary from key researchers, and provides leads into the literature for further reading.



## What do we mean by technology?

Four different perspectives have been used to define technology (Geisler, 1999):

Perspective	What technology contains	Features of technology	Prospective outcomes of technology
<b>Technology as artefact</b>	Tools Solutions Devices Processes	Operationality Functionality Enabling qualities	Helps develop products and services Helps make organisations more efficient
<b>Technology as management and information</b>	Information Intelligence Techniques Methods Approaches	Savings in time and cost Efficiency of operations	Helps in better communication Helps in creating new realities
<b>Technology as a process</b>	Stages of the innovation process	Enables ideas to become reality	Publications Patents New and improved products, processes and services
<b>Technology as a dimension of the organisation</b>	Core competencies Basic strengths of the organisation Dreams and aspirations	Differentiates among units and organisations	Improved competitiveness in the marketplace

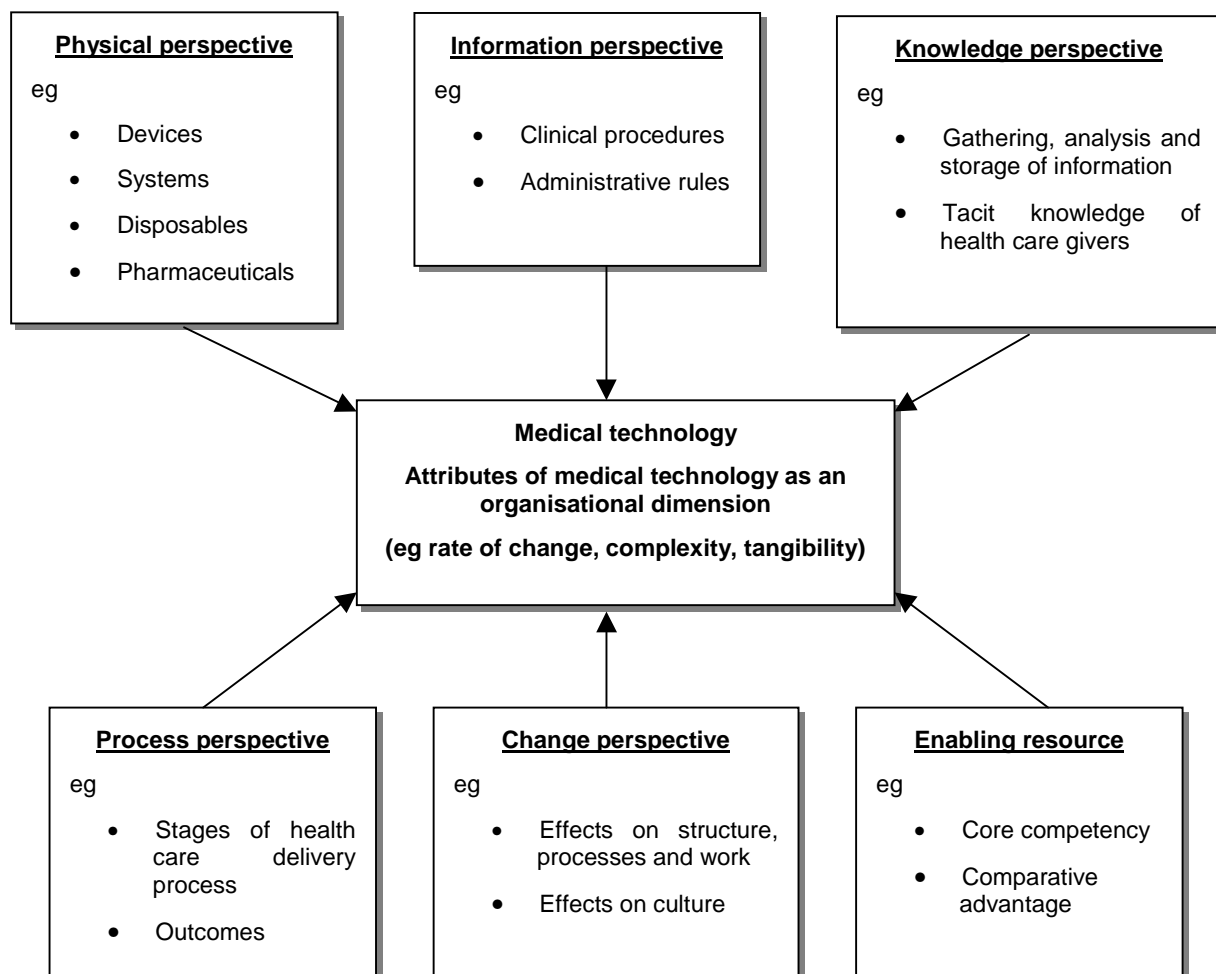
In this paper, all four perspectives are used. The term ‘technology’ includes specific tools (eg a syringe, a drug, a diagnostic reagent), methods for collecting and processing information (eg health informatics), methods for creating knowledge (eg clinical trials, systematic reviews of evidence), assemblages of machinery (eg X-ray machine, syringe driver) and assemblages of machinery and expertise (eg cardiac catheter lab, hospital).

Most analyses of the magnitude or intensity of use of medical technology concentrate on the first perspective, that is, technology as artefact, or a physical perspective on technology. The physical perspective lends itself to measurement, impact analysis and economic evaluation. However, the physical perspective tends to restrict both the understanding of the nature of technology and assessment of its effects from a range of different perspectives (eg the impact of medical records on health care delivery). A more expansive perspective on the nature of technology facilitates a broader consideration of the actual and potential contributions (both positive and negative) of technology to health and health services.

Narrow perspectives on technology in health care have limited the comprehensiveness of research into the technology in health care and understanding of the impact of technology on health care. Geisler (1999) has

proposed a broad, multi-dimensional model for defining medical technology (figure 1) in order to provide a framework for comprehensive evaluation of the impact of technology on healthcare and health, in terms of aspects such as cost, health impact, design of health care delivery systems and knowledge and skill acquisition. For example, computerised patient records can influence the way in which medical care is delivered, in term of location of medical care and manner of use of different medical specialties.

**Figure 1: A model of integrative, multi-perspective definition of medical technology**



In a recent call for papers on health technology by *The British Medical Journal*, technology was defined as ‘any intervention which influences health and society’ (Berger, 1999). Perhaps this definition captures the breadth of technology represented by the Geisler model.

An inkling of the scope of application of technology in health can be gained from examining the range of applications of information technology in health care (Geisler, 1999):

- |  |
|--|
| <p><b>Administrative applications of information technology</b></p> <ul style="list-style-type: none"><li>• Computerised patient records</li><li>• Computerised admission data, accounting and billing</li><li>• Automated referral and training</li><li>• Electronic mail and other automated communication</li><li>• Managerial decision support systems</li><li>• Automated linkages between databases</li><li>• Automated hospital information systems</li><li>• Electronic networking with suppliers and regulators</li></ul> <p><b>Clinical applications of information technology</b></p> <ul style="list-style-type: none"><li>• Telehealth and telemedicine</li><li>• Medical imaging and signal processing</li><li>• Neural networks and pattern recognition</li><li>• Smart cards</li><li>• Knowledge-based systems in clinical decisions</li><li>• Linkage to computerised patient records</li><li>• Automated clinical training and education</li><li>• Clinical intelligent support systems.</li></ul> |
|--|

This broad perspective on the nature and roles of technology in health has several benefits:

- decision-making in health care resource allocation will be better informed about the potential contributions that technology can make to addressing needs and to problem-solving; and
- evaluation of medical technology will be more comprehensive in terms of types of technology considered for evaluation, and in terms of assessing impact on health care in areas other than proximate cost and effectiveness.



## **Benefits of Modern Health and Medical Technology**

### **Technology and population health**

In addition to the fundamental technologies of civilisation described above, a number of technologies have had a profound and positive effect on the health of people around the world. These include sewage and potable water supply systems, vaccines, iodine supplements, oral re-hydration therapy and antibiotics. A recently discovered example of this kind of technology is the effect of Vitamin A supplements in reducing the severity of measles in children.

### **Evidence of the impact of health care technology on health**

The impact of public health interventions on population health has been substantial. Over the 20<sup>th</sup> Century, life expectancy in industrialised countries has increased from around 45 to 75 years. What has been the impact of clinical care on this improvement in population health? Few analyses of this issue are available.

An influential analysis of the decline in mortality in England and Wales from the mid-19<sup>th</sup> Century showed that around three-quarters of the decline in mortality could be attributed to a decline in infectious disease deaths. Around three-quarters of the decline in infectious disease deaths occurred before the introduction of effective medical interventions such as vaccines and antibiotics (McKeown, 1971). Most of the reductions in mortality are attributed to general improvements in living conditions arising from the technological developments in society described above. Bunker and colleagues at University College London have estimated that, of the 30 years improvement in life expectancy this century, around five years is due to clinical care (Bunker, Frazier and Mosteller, 1994). Their analysis also suggests that medical care has the potential to contribute an additional two years to life expectancy, although such an estimate must be largely speculative. Medical care would also have contributed to reducing pain and suffering, although Bunker et al (1994) were unable to quantify this benefit. Estimates of the impact of public health interventions and medical care are available for specific disease groups.

In the latter part of this century, vaccines have had a major effect on the incidence of communicable diseases (table 1), as have diagnostic tests for communicable diseases (table 2).



**Table 1: Impact of immunisation on vaccine preventable diseases in the USA**

Disease (peak year in USA)	Cases reported in USA		Overall decrease
	Peak year	1993	
<b>Diphtheria (1921)</b>	206,939	0	100%
<b>Measles (1941)</b>	894,134	281	99.9%
<b>Mumps (1968)</b>	152,209	1,640	98.9%
<b>Pertussis (1934)</b>	265,269	6,335	97.6%
<b>Paralytic poliomyelitis (1952)</b>	21,269	4 (vaccine related)	100%
<b>Rubella (1969)</b>	57,686	195	99.6%
<b>Congenital rubella syndrome (1964-65)</b>	20,000	7	99.9%
<b>Tetanus (1923)</b>	1,560	43	97.2%

Source: US Department of Health and Human Services Public Health Service

**Table 2: Impact of screening donated blood on public health and medical costs in the USA**

Agent	Period	Infections averted	Medical costs saved
<b>HIV</b>	1985-1993	43,000	\$2,400 million
<b>Hepatitis B</b>	1971-1993	918,000	\$145 million
<b>Hepatitis C</b>	1986-1993	326,000	\$685 million

Source: US Department of Health and Human Services Public Health Service

The last 40 years has also seen a substantial decline in the incidence of and mortality from coronary heart disease. In Australia, mortality from coronary heart disease is declining at an annual rate of 5.1 per cent among males and 4.2 per cent among females (AIHW, 1998). Explanation for these reductions can be found in the results of computer modeling using bio-mathematical models based on data from the USA. There, over the last three decades, coronary heart disease incidence has declined at about one per cent annually while mortality has declined between two per cent and four per cent annually. This reduction has been attributed to reduced prevalence of risk factors in the population reducing overall incidence, reduced risk factors in those with coronary heart disease causing fewer events (heart attacks and deaths), and other improvements in the treatment of patients with coronary artery disease. The computer model was used to quantify the relative contribution of these explanations to the observed declines in incidence and mortality. The analysis suggested that 25 per cent of the decline in coronary heart disease mortality could be attributed to primary prevention, and 71 per cent of the decline due to improved treatment of those with coronary heart disease. Table 3 presents the proportion of the reduction in coronary heart disease explained by different improvements in risk factors and treatment. Here,

specific medical technologies were found to be the major causes of the reductions in coronary heart disease mortality.

**Table 3: The proportion of the reduction in coronary heart disease between 1980 and 1990 in the USA explained by improvements in risk factors and treatment**

<b>Improvement</b>	<b>Proportion explained %</b>
<b>Lifestyle</b>	
Smoking	6
<b>Treatment</b>	
Diastolic blood pressure	14
Medical and surgical treatment of coronary artery disease	29
Treatment of acute myocardial infarction	15
<b>Lifestyle and treatment</b>	
Cholesterol	33

Source: Hunink, Goldman and Tosteson (1997)

This analysis focuses on the proportion of the reduction in mortality from a particular disease that can be explained by different lifestyle and treatment factors. Another approach is to examine improvements in life expectancy that can be attributed or could be gained from a particular health technology. Examples of these gains are presented in table 4.

**Table 4: Average gain in life expectancy in months from selected health technologies**

Disease and intervention	Target population	Gain in life expectancy (months)	
		Males	Females
Estrogen replacement therapy after hysterectomy	Women aged 50 y	-	13
10 years of biennial mammography	Women aged 50 y	-	0.8
Pap smear every 3 y for 55 y	Women aged 20 y	-	3.1
Annual fecal occult blood test every 5 y for 25 y plus barium enema or colposcopy	50 y olds	2.5	2.2
Reducing diastolic blood pressure from >105 mm Hg to 88 mm Hg	35 y olds	64	68
Reducing cholesterol from >7.8mmol/L to 5.2 mmol/L	35 y olds	50	76
Hormone replacement therapy with estrogen and progestin in 50 y old woman with history of coronary heart disease		-	11 to 26
Myocardial revascularisation by coronary artery bypass or angioplasty in men with disease of:	one vessel	1-7	-
	two vessels	0-8	-
	three vessels	4-14	-
Implantable cardioverter-defibrillator in survivors of cardiac arrest with recurrent ventricular arrhythmias that do not respond to conventional therapy		36-46	
Chemotherapy in patients with extensive small-cell lung cancer		6.6-8.2	
Prophylaxis against <i>Pneumocystis carinii</i> pneumonia and toxoplasmosis in patients with advanced HIV disease		5.3	
Appendectomy in patients with suspected acute appendicitis	Probable	9-31	
	Possible	2-5	

Source: Wright and Weinstein (1998)

These data illustrate that preventive and medical technologies can be effective in improving health. However, there may be unanticipated consequences of these improvements: While reducing or eliminating disabling non-fatal conditions such as arthritis and back complaints may result in a decline in life lived with disability, reducing highly fatal diseases such as cancer may have the adverse effects of increasing life lived with a disability (Nusselder et al, 1996) and increasing costs of health care, the subject of the next section (Bonneux et al, 1998). A seemingly wholly desirable health improvement resulting from a particular health technology may have adverse consequences that should be included in analysis to gain an accurate picture of the impact of a health technology.

In the Australian context, one approach to assessing the health benefits of technology would be to compile an inventory of the health benefits of individual items on the Medicare Benefits Schedule and the Pharmaceutical Benefits Schedule, at least for those items that are used frequently or are particularly expensive. This information is being collected for new items that are added to the schedule as part of the mechanisms for

approving new items, but many current items will remain in common use. Also, for some common items it would be very difficult to quantify health gain. For example, general practitioner (GP) attendance items are provided for a wide range of services, many of which are provided for patient reassurance or information, and have little or no tangible health benefit. On the other hand, some GP attendances have tangible health benefits that can be quantified (eg immunisation, Pap tests, medical treatment of specific conditions). More progress might be made with the Pharmaceutical Benefits Schedule, but there many medications are prescribed for a wide variety of conditions and may be prescribed where there is no clinical indication (eg antibiotics).

While conceptually appealing, the vision of an inventory of the health benefits of individual items on the Schedules will have to remain a vision for many of the most common items. None-the-less, it would be useful to assemble what we do know about the effectiveness of technology in terms of a comprehensive inventory like the Schedules, and to identify specific priorities for research into the health effects of specific technologies from examination of usage of items on the Schedule.



## **Cost Implications of Modern Health and Medical Technology**

The impact of technology on health care costs has two broad aspects: the impact of individual items of technology on cost and the aggregate impact of technology on cost. We examine the aggregate impact first, and then the specific.

### **The impact of technology on health care costs in the aggregate**

One study (Murphy, 1998) reports that it is impossible to say with any certainty that new technology has led to more or less spending on health care. This view would appear to be in the minority. Fuchs (1999) who is Professor Emeritus of Economics, Stanford University, comments on the costs of technology in health care thus:

Most experts believe that “technology” is the driving force behind the long-term rise of health care spending. In a survey of fifty leading health economists in 1995, 81% agreed with the statement, “the primary reason for the increase in the health sector's share of GDP over the past 30 years is technological change in medicine”. Expenditures grew primarily because the medical system was delivering more and better services to patients: new drugs, magnetic resonance imaging, angioplasties, hip replacements, and many other costly interventions. Advances in medical technology have made it feasible and desirable to do more for each patient and to intervene with more patients.

In the United Kingdom, it is anticipated that the four main pressures on funding and efficiency of the National Health Service will be demography, morbidity, new technologies and changing expectations (Harrison et al, 1997). It is predicted that demographic change will increase expenditure by 8.25 per cent and changes in morbidity (in the absence of unforeseen events such as a major infectious disease outbreak) will have no impact on expenditure. The major cost drivers will be technological change and changing expectations. This pattern is similar to that expected in Australia. The report of the Health and Medical Research Strategic Review (1999) provides an estimate of the likely impact of increasing application of technology to health system expenditure in Australia from 1996 to 2016 (table 5). Increased demand for or supply of services after accounting for population growth and aging comprises almost three-quarters of projected expenditure growth. This is consistent with the analysis of Fuchs (1999).

**Table 5: Projected Australian health system expenditure in 2016 (A\$ billion in 95-96 prices) assuming continuation of recent real growth rates, by components of expenditure growth from 1997**

Areas of health expenditure	A\$ B	Compound annual growth rate %
<b>Expenditure in 1997</b>	43.2	
<b>Increased expenditure due to:</b>		
•Population growth	8.5	0.9
•Ageing of the population	5.4	0.5
•Increased demand for or supply of services	35.8	2.5
<b>Projected expenditure in 2016 at current real growth rates</b>	92.9	3.9

Source: Health and Medical Research Strategic Review (1999)

The recent upsurge in health insurance premiums in the United States has been caused, at least in part, from public demand to use the latest technologies, irrespective of costs and health benefit (Greenberg, 1998). Up to 50 per cent of the inflation in health care expenditure in the US may be due to the diffusion of new technologies (Newhouse, 1993).

New technologies offer new opportunities for treatment or raise the quality or outcome of treatment, and thus increase the number of people who may benefit, even though particular items of new technology may be cost saving. New technologies, consequently, tend to create pressure to increase spending (Harrison et al, 1997). Continuing and increasing pressure on health services to increase utilisation of technology come from competition between health care providers, new areas of medical applications of technology and regulatory requirements (Geisler, 1996). This is being spurred on by direct pharmaceutical company and physician advertising to the general public. This is consistent with the observation that growth in medical expenditure due to technology may be due to increased use of drugs, small tests and procedures rather than from increased use of high unit cost technologies (Moloney et al, 1979).

A recent review in the *British Medical Journal* (Harrison et al, 1997) was unable to identify examples where new technologies had reduced spending in the health system as a whole rather than on individual patients. The absence of examples was attributed to a lack of research on the overall effects of introducing new technologies on health systems. The article concluded:

There is therefore no sure way of forecasting the effect of new technologies on NHS [UK National Health Service] expenditure. But in the face of bullish forecasts of what technology may offer in the future as well as evidence of the increasing number of technologies available each year, the opportunities for introducing new technologies are likely to grow.

## The impact of specific technologies on health care costs

Does analysis of specific technologies shed any light on the expectation that the impact of technology will be to increase aggregate expenditure? Male impotence treatment with Viagra has cost around \$2 billion since it was introduced in early 1998, with a large share of the drug going to men who hadn't been treated for impotence. This technology has clearly increased health expenditure.

Advances in the treatment of peptic ulcer disease over the last 30 years provide an important example of the more complex impacts of technology on the cost of treating one disease (Murphy, 1998). On the diagnosis side, the replacement of X-ray (barium meal) by flexible endoscopy has substantially increased the cost of managing peptic ulcer (table 6). On the treatment side, the introduction of H<sub>2</sub>-receptor antagonist drugs increased the cost of treatment in comparison with surgical treatment (table 7). The subsequent introduction of *Helicobacter pylori* eradication therapy then reduced the cost of treatment to below the costs of all previous treatment modalities.

**Table 6: Cost of different diagnostic technologies for peptic ulcer (Murphy, 1998)**

Diagnostic technology	Cost of diagnosis
X-ray	UK£ 120
Endoscopy	UK£ 673 – 748

Source: Murphy (1998)

**Table 7: Cost of different treatment technologies for peptic ulcer (Murphy, 1998)**

Treatment technology	First year	Subsequent years of treatment
Surgery	UK£ 393-546	UK£ 27
H <sub>2</sub> -receptor antagonist drugs	UK£ 193	UK£ 193
<i>Helicobacter pylori</i> eradication	UK£ 83	UK£ 15

Source: Murphy (1998)

An important issue in the cost of technology is the relationship between cost and volume. Recent research illustrates the complexities of this relationship for a variety of minimally invasive surgical procedures (Shine, 1997): Coronary artery angioplasty is much less costly than the procedure it replaces, coronary artery bypass grafting. However, the ease of performing the procedure, the lower morbidity and the reduced length of hospital stay has created a boom in the number of angioplasties performed in the USA, with only a small reduction in the rate of increase in bypass grafting (see table 8 below). The introduction of angioplasty has seen a massive increase in the total number of coronary procedures, due in part to administration of the procedure to people not suitable for bypass grafts (American Heart Association, 1996; Hannan et al, 1994).



For laparoscopic cholecystectomy, which replaced cholecystectomy by abdominal incision, there was a 40 per cent increase in cholecystectomy rate, without any indication of unmet need (Legoretta et al, 1993). Even though the laparoscopic procedure was 25 per cent cheaper, the increased usage resulted in the overall cost of gall bladder surgery increasing by 11 per cent. While minimally invasive surgery is advocated because of its lower cost, careful cost analysis has found that laparoscopic hysterectomy is, in fact, more expensive than abdominal and vaginal hysterectomy (Dorsey et al, 1996; Weber and Lee, 1996).

Examination of a range of individual technologies would seem to confirm the results of analysing the effects of technology on aggregate health expenditure: Technology increased health expenditure. However, the introduction and use of technology is amenable to control, unlike demographic changes (Harrison et al, 1997), raising at least the prospect of being able to control the cost impacts of technology.

## Creation, Diffusion and Evaluation of Technology

### One dream of the future for technology in health care

A senior cancer researcher in the UK presents the following “dream of the future” for technology in health care (Lane, 1998). This dream provides a succinct perspective on the range of technologies that are expected to become important over the next quarter century:

In 25 years time we will be seeking evidence-based medicine. By that, I mean that all our lifestyle advice, our environmental and legislative controls, our preventive vaccines, our molecular diagnostics, and our new treatment protocols will be based on transparent, openly available, statistically meaningful scientific evidence. This evidence will encompass not only treatment responses (and rigorous audit) but also realistic measures of patients’ benefit and accurate financial data. It will be available to all through the home voice-activated mini-computer interface with the supernet. We seek an end to anecdotal medicine for the treatment of cancer. Informed patients will interact dynamically with trained physicians to plan individual treatments. 25 years from now we will be able to determine accurately, before treatment, the probability of a suitable therapeutic or palliative response in the individual tumour in the individual patient. No treatments will be given, except placebos, if they have no chance of positive effect.

In 25 years time we will have developed a new generation of cheap and effective treatments for cancer that are not toxic to normal cellular components and that accurately target either the specific genetic defects in the tumour being treated or target the specific physiological state of the tumour and its interaction with the surrounding stroma. In 25 years time the combination of the “2005 global smoking-ban act” and widespread adoption of chemopreventive dietary supplements, combined with annual whole-body health scans based on new imaging methods and DNA-chip-based mutation screens of blood, urine, stool and breast effusions, will have halved the incidence of malignant metastatic cancer in the population. Accurate imaging, precise, limited-access robotic surgery, and pre and post surgical systemic therapies and early treatment will have reduced the incidence of recurrence even further. Novel palliative treatments and rational use of analgesics will provide a good death in those remaining cases that resist treatment.

### Examples of promising technologies

This excerpt paints an exciting picture of the benefits in prospect from technological development over the coming decades. To explore this in a little more detail, it is worthwhile to examine some technological innovations currently under development that have been taken from recent articles in *New Scientist*, and their health and economic implications:

A device that is worn like a wrist-watch and automatically and painlessly measures blood glucose every 20 minutes could replace painful finger-prick blood tests that diabetics currently use to monitor diabetes control. It is under review by the United States Food and Drug Administration. Improvement in diabetes control in compliant patients would reduce clinical complications and treatment costs and significantly improve quality of life.

Negative breast biopsies following mammography may be replaced or reduced by a hand held probe that passes a minute electric current through the breast. Tumours are about 40 times more conductive than normal tissue, and the scanner generates a computerised image that increases the reliability of cancer diagnosis before biopsy. This procedure would potentially reduce anxiety among women with positive mammograms. It may reduce cost if used after screening by reducing the number of biopsies, but would probably increase cost if used for screening instead of mammography, which is an embarrassing and painful procedure for many women.

A vaccine has been developed that cures 50 per cent of cases of psoriasis, an otherwise incurable autoimmune skin disease that affects 100 million people world-wide. The vaccine blunts the attack of lymphocytes against the patient's own skin cells. The vaccine would be the first to eradicate a disease already in the body rather than preventing it from taking hold. The technology may have application for other autoimmune diseases such as rheumatoid arthritis. This could produce significant health improvement and reduce treatment costs, with a single or small number of vaccine shots eliminating the need for life-time pharmaceutical treatment and giving much improved disease control.

A bacterium called *Acetobacter xylinum* has been used to make narrow tubes of cellulose that make good substitutes for blood vessels. The tubes grow in the space between two ceramic cylinders, and can be tailor-made for particular parts of the body. The tubes do not seem to provoke immune reactions when implanted in rats. Instead, they are colonised inside by the endothelial cells that line normal blood vessels and covered on the outside by local connective tissue, integrating the tube into the body. This technology would have widespread application in vascular diseases that are not currently amenable to surgical treatment, leading to large increases in health care costs. It could also be used to build molecular scaffolding for new organs grown from tissue culture, which would promote organ replacement surgery.

Three beams of ultrasound focussed on a point could be used to destroy tumours without endangering nearby health tissue. This would be particularly valuable for treating brain tumours, where surgeons will be able to reach brain lesions with minimal surgical intervention. If successful, this technology would greatly reduce morbidity and cost associated with invasive brain surgery, reduce length of stay and even lead to some brain tumours being treated as day only or outpatient procedures.

A prosthetic limb has been developed that allows amputees to use the limb for purposive movements much more rapidly than for current prostheses. The prosthesis includes a chip that uses genetic algorithms to learn which nerve impulses in the limb stump correlate with the intended movement of the user. This innovation would improve the quality of life of amputees and increase their independence at modest cost, with a possible reduction in assistance needed with activities of daily living.

Embryonic stem cells are those that have the potential to become any tissue in the body. By combining cloning technology with the isolation of stem cells from cloned embryos, it may be possible to grow tissue and organs from patient's own cells, overcoming problems of rejection and infection. This would lead to a large increase in organ replacement surgery, with major cost implications. It could also be used to treat degenerative diseases like Parkinson's. This would greatly improve quality of life and increase lifespan.

Hand-held machines that perform genetic tests are under development. They will use biochips, in which DNA micro-array technology is combined with electronic signalling and read-out technology on a single chip of silicon. Currently, there are major concerns about the ethical implications of genetic testing. These would increase significantly if simple, portable genetic testing technology were available, with potential for significant community discord.

Surgical tools and needles etched from silicone, like computer chips, may make incisions and injections painless. These instruments would be ten times sharper than their metal counterparts, and vibrate at ultrasonic frequencies. It may also be possible to add silicon-based sensors into the instruments. This technology would have widespread application and could significantly increase the cost of health care.

These examples present technologies that may or may not ultimately enter the clinical armamentarium. However, they show the possible health and cost implications of some technologies that are in the development pipeline. In many of the examples, the technology would increase health care costs by enabling costly treatment of conditions that are currently difficult or impossible to treat, supporting the arguments about the likely effects of technological progress on health care costs. However, some technologies do have the potential to reduce cost and significantly improving health, as illustrated by the psoriasis vaccine.

Anecdotally, many technologies that seem to offer great promise never become commercially available. This could be for a variety of reasons: The initial claims are speculative and subsequent research does not confirm the initial promise; funding cannot be obtained for further research or commercialisation; a safe, effective and economic product cannot be developed; or commercial competitors win in the marketplace. On the other hand, currently unanticipated technologies or technologies with little promise may come to have dramatic impacts on health care.

The community has a high level of interest in new technology, and in particular health technology. This is reflected in the media frequently reporting new discoveries and "breakthroughs". It is of concern that often the hopes of patients and their families may be exploited by premature disclosure of "breakthroughs" and by speculation that is unfounded or irresponsible.

## Sources of technology

How will these technological advances arise? Technology in health care may come from a variety of sources: Technology may be developed in response to a specific health problem (eg the current efforts into developing gene therapies for genetic diseases; the development of detection kits for HIV). Many technological developments result from clinicians in hospitals discussing their needs with technology developers.

New technology may come from a discovery or technological development that was not originally envisaged to have any application to health (eg magnetic resonance imaging came from fundamental physics research into nuclear magnetic resonance; buckyballs of carbon atoms are being developed into a gas for inhalation during nuclear medicine lung scans).

New technology may come from basic research into a health or biological problem (the discovery of helicobacter pylori as a cause of peptic ulcer disease, leading to specific anti-helicobacter antibiotic regimens to treat peptic ulcer). Finally, and unpredictably, new technology may be discovered by serendipity. The chance observation that milking maids, who were occupationally exposed to cow pox virus, did not have small pox scars has led to the development of vaccines against many communicable diseases. Inoculation with cow pox was the first effective immunisation procedure.

## Encouraging the development of new technology in health care

The many pathways that bring technological advances to health care mean that the process is largely unpredictable. However, certain environments favour the development of new technology in health care:

- health care services that are research oriented, in that clinicians participate or direct research and where more fundamental research is in close geographic proximity to service delivery;
- health care services that have a wide spread of disciplines that facilitates the development of cross-discipline linkages and collaborations;
- where high technology research and development activities are located close to major health care facilities, such as major teaching hospitals;
- where networks exist or have been encouraged to develop between health care services, research centres and industry partners, as in the Cooperative Research Centres program;
- where opportunities for financial rewards are available for innovators in the public sector; and
- where venture capital and intellectual property services are readily available, and tax and other public expenditures encourage innovation.

These and related issues have recently been covered in depth in the Health and Medical Research Strategic Review (1999).

From a societal perspective, the most desirable technologies are those that are highly effective and have low cost. Examples are vaccines, and, in developing countries, iron and iodine supplements to pregnant women and newborns. Unfortunately there are significant impediments to the development of effective, low cost technologies (Shine, 1997): The low cost means that they offer limited economic rewards. For example, while the marginal cost of manufacturing a technology such as a vaccine may be low, the low market price that would be obtained in relation to development costs (eg \$2-300 million) can make development commercially prohibitive because it is not possible to recover this investment. A successful vaccine may also reduce its own market by reducing the risk of contracting the disease among non-immunised people. The economics of vaccine

development is also affected by the small but predictable number of medico-legal claims from adverse reactions to vaccines.

Clearly, to stimulate the development of these technologies, public sector involvement is required in addition to private sector research and development (Shine, 1997). This involvement could occur at all stages of development and use: The public sector already funds significant levels of basic biomedical research that underpins the development of all new technology. The public and private sectors could develop joint ventures for research, development and clinical trials. Governments could provide market support such as dual pricing strategies, where public good prices are charged in developing countries and profit-making prices are charged in developed countries. Governments could also provide appropriate limitation of public liability or government indemnification for liabilities for socially desirable, low cost technologies, as currently occurs with blood products in Australia.

One further barrier to the development of low cost and effective technologies (as well as other technologies) is public pressure in relation to technologies that offend particular social groups. In recent years, public pressure has restricted the development and distribution of contraceptives, genetically modified food and research on animals and fetal tissue. Genetically modified food is an especially interesting example, as there is virtually no evidence of adverse health or other effects from genetically modified food and it has been widely accepted in the United States, yet it has provoked much controversy in Europe and Australia. While the public concerns may have a legitimate basis in terms of specific value systems and unforeseeable risks, they can inhibit the development of technologies judged as cost-effective by people with other value systems.

## **Factors that influence the uptake of new technology**

Occasionally there is a technological block-buster like Viagra that causes an immediate increase in usage and health expenditures. Viagra was taken up rapidly because, as a technology, it had the following characteristics of technologies that diffuse rapidly: there is a large unmet demand, the technology is easy and safe to apply, the cost is affordable and positive publicity about the technology is widespread.

More frequently, technologies are introduced and use increases gradually over the following years (table 8). None of the technologies listed in table 8 was new in 1987. Under this pattern of diffusion, they have little initial impact on expenditure, but have progressively greater impact over time as clinical experience grows and physicians become confident about applying the procedure to more people. Fuchs (1999) examined 35 procedures, and after adjusting for age and demographic changes, found the usage rate in the elderly increased by 11.1 per cent per year for men and 10.7 per cent for women. Utilisation increases of this magnitude are major drivers of health service costs. As discussed in the previous section, table 8 shows that usage of coronary artery bypass grafts has increased even with increasing use of coronary angioplasty, which was expected to substitute for bypasses.

**Table 8: Annual percentage increase in procedure rate per 100,000 between 1987 and 1995 in the USA**

Procedure	Men aged 75-79 %	Women aged 75-79 %
Angioplasty	20	17
Coronary artery bypass grafts	9	11
Cardiac catheterisation	10	10
Carotid endarterectomy	10	9
Hip replacement	18	19
Knee replacement	12	9
Laminectomy	8	7

Source: Fuchs (1999)

Sometimes factors other than cost limit access to cost-effective technologies. For example, childhood immunisation is a very inexpensive and highly effective technology, yet Australia, along with several other developed countries, has had a low rate of childhood immunisation after the first couple of immunisations, even with free vaccines and inoculation. This slow diffusion of immunisation can be attributed to a lack of institutional impetus to promote immunisation after children leave the baby health network, weak incentives for doctors to provide immunisation services, limited availability of information on the benefits of immunisation and mischievous publicity campaigns by anti-immunisation activists. Low immunisation rates have now been addressed in Australia through a national immunisation register, payments to doctors for vaccinating children and financial incentives to parents.

The diffusion of *helicobacter pylori* eradication therapy to treat peptic ulcer disease has also been slow and incomplete, but for other reasons. There was initially great scepticism in the scientific community following the discovery in Western Australia of the role of *helicobacter* in peptic ulcers, there was inertia in the medical community to move away from long-standing ways of treating ulcers, and the economic interests of pharmaceutical companies meant that they devoted little marketing effort to promoting antibiotic treatment of ulcers. This has resulted in substantial avoidable public expense and private suffering from peptic ulcer disease over the last decade.

Unfortunately, expensive new health care technologies with potentially major impacts on cost or health are frequently used haphazardly before their effectiveness and clinical appropriateness has been assessed (Stevens, Robert and Gabbay, 1997). Furthermore, their diffusion is unorganized and varies according to ease of adoption, clinical enthusiasm and marketing. Frequently doctors shift to prescribing newly released medications because of marketing activities, even though the health benefits in most patients are minimal and the cost is greater. There have been many demonstrations of large geographic variations in the rates of utilization of specific technologies (eg coronary bypass) with no discernable differences in health outcomes. The cost implications of these variations are large. These variations highlight major deficiencies in clinical understanding of the applicability of those technologies in specific clinical situations. Given their cost implications alone, these variations should be the subject of major investments in health services research aimed at developing and

applying evidence-based clinical criteria. It is noteworthy that the studies of geographic variations allow us to identify variations in practice that are present at the level of individual practitioner but are not observed unless appropriate comparative studies are done.

## Controlling the uptake of technology

Technologies may be loosely grouped into high technology (those requiring complex support systems eg organ transplantation) and low technology (eg drugs, simple blood tests or simple operative procedures). Typically, high technologies have clear points of decision-making that make the management of their introduction and diffusion easier, except in the case of the new pharmaceuticals and medical devices in industrialised countries, where their introduction requires certification by national authorities.

Early identification of technology is a potentially important contributor to managing the introduction of technology into clinical practice. While few, if any, countries have good mechanisms for early identification of technology prior to its introduction in some form, a number of studies have explored methods for doing this (Stevens, Robert and Gabbay, 1997). Key issues in selecting potential future technologies for further examination include (Stevens, Robert and Gabbay, 1997):

- the likely time of the impact of the new technology;
- the likely size of the impact;
- the most significant aspects of the impact (eg cost, benefit, organizational); and
- the state of development of the technology.

Since the accuracy of prediction decreases exponentially into the future, it is necessary to continue efforts to identify emerging technologies. Efforts to detect changes in technology must also detect changes in the use of existing technologies.

In health systems around the world, there is recognition of the need to both increase the effectiveness of health expenditure and constrain future increases in health expenditure (Ross et al, 1999). Increasing demand for existing technologies and demand for new technologies are important driver of increasing health costs. The difficulties in controlling increases in the utilisation of technologies in place are well-described by Bill Ross and his colleagues (1999) in Volume 3 in this Health Financing Series.

## Evaluating technology

Economic evaluations such as studies of cost-effectiveness (which measure dollars per life years saved) and cost-utility (which measure dollars per quality adjusted life years saved) are a crucial component of health technology assessment. Evaluation of technology is desirable to ensure its safety and efficacy, to investigate its appropriate uses and distribution, and to set prices.

For new treatments, health outcomes should be monitored for a sufficiently long period after treatment to accurately assess the health impact of the treatment. This is particularly important for novel treatments, where



unanticipated long-term outcomes may occur. Further research and development is required into methods for defining the values of technologies. This includes measurements that go beyond mortality and morbidity to include quality of life adjustments such as QALYs (quality adjusted life years).

Following the introduction of new health technologies, many factors may change that have an impact on their cost-effectiveness: Both costs and clinical effectiveness may vary between the controlled setting in which a clinical trial is conducted and use in routine practice. Dosage regimens or modes of delivery may change over time as clinical experience grows. For example, in the USA the Health Care Financing Administration determined that 80 per cent of the US\$6000 annual cost of human erythropoietin (epo) therapy for haemodialysis patients would be borne by Medicare and 20 per cent by the patient. In response, many dialysis units reduced the dose of epo while continuing to receive the \$6000. Unexpectedly, the more gradual increase in red blood cell synthesis produced by the lower dose was found to reduce the risk of side-effects from epo (Mason and Drummond, 1997). The early economic evaluations suggested a cost per quality adjusted life year in the range UK£ 66,000 – 103,000 per QALY. Following changes in clinical practice, a later evaluation estimated cost-effectiveness at UK£ 20,000 per QALY. Here, the economic evaluation that led to price setting occurred too soon, illustrating the principle that early economic evaluation may be misleading.

The patient groups for whom the treatment is applicable may change over time. For example, US data show that, for a range of common clinical procedures, utilisation rates among the elderly have increased substantially over the last decade (see table 8). These changes would doubtless invalidate the results of earlier economic evaluations.

For these reasons, economic evaluation of new technologies should not just occur at the beginning of the useful life of the technology, but should be periodically reviewed and updated as required.

New biotechnologies provide particular challenges for health technology assessment (Mason and Drummond, 1997): Where biotechnology products fill major gaps in therapy, methods of measuring health outcomes may not be available. Price setting for biotechnology products can be problematic, especially where there are no existing therapies for comparison. High prices for novel ‘magic bullet’ therapies may be necessary to repay development or manufacturing costs, and may be justified if health gain is substantial and consequent cost-effectiveness reasonable. Finally, the costs of economic evaluation and time taken for regulatory approval may be unaffordable to small biotechnology companies that rely on venture capital. This is doubtless one of the factors behind the trend for biotechnology companies to form strategic alliances with large pharmaceutical companies (Read and Lee, 1994).

A forthright view on the creation, diffusion and cost of health technology comes from Professor Emeritus Victor Fuchs (1999) of Stanford University:

Because technology is the principal force behind the growth in use of services, the most important strategy for slowing that growth must be to slow the development and diffusion of new technology. One way that public policy affects technology is through Medicare, Medicaid and other publicly funded health insurance programs. Government’s willingness to pay for particular services influences

the adoption and diffusion of technologies, and the pace of adoption influences private investment in research and development. Government also influences the development and diffusion of technology by subsidizing medical research and the training of specialists and sub-specialists.

Most present thinking in Washington is to accelerate the rate of growth of medical technology. Proponents of this strategy usually assert that new technology will reduce spending. On balance, it has not worked out that way in the past, and there is no particular reason to think that it will in the future. A technological advance may cut the cost of performing a particular intervention, or of treating a particular patient, but expenditures depend on the number of units of service as well as on the price per unit. For example, technological advances in the computer industry have led to spectacular decreases in price per unit of service; nevertheless, spending on computers has soared. Much the same happens with most technological advances in medicine.

Nevertheless, a practical approach is required to enhance the cost effective utilisation of new technologies. A range of public policy approaches has been proposed to achieve this (Shine, 1997):

- technology that has a unique purpose should only be reimbursed when used for that purpose;
- procedures that accelerate the assessment of efficacy and effectiveness of new technologies for other uses should be accelerated;
- technology that is an advance over existing technologies should be reimbursed only when applied to its appropriate uses for the incremental advantage that it represents. It should not simply replace all of the applications of the less expensive, less advanced technologies;
- consideration needs to be given to dealing with redundant technologies;
- manufacturers and producers of new technologies should be encouraged to define clearly the learning curve and educational requirements before a new technology is applied. This should include an assessment of the relative value of the technology when used in settings with different levels of throughput; and
- research should be supported that identifies incentives to improve the utilization of low-cost technologies and identifies obstacles to their wide-spread prudent application.



## **Implications for Australia's approach to Health Technology**

Since sickness and death are highly undesirable but inevitable, there will always be pressure to ameliorate and postpone them. This means that there will always be demand for the latest and best health care, and technological advances will always put pressures on health expenditure. With the technological advances in prospect resulting from scientific advances in materials, information technology and biotechnology, cost pressures on health systems will increase. Australia has the opportunity to position itself as a producer of these goods for export, while developing sophisticated means of maximising value for money in its consumption of these goods.

Recent major policy developments in health and medical research funding and emphasis on biotechnology development in Australia arising from the Health and Medical Research Strategic Review (1999) and the venture capital recommendations of the Review of Business Taxation have the potential to reposition Australia as a more significant, if inevitably minor, player in the global production of health technology.

On the consumption side, a strong and bipartisan commitment to universal national health insurance through Medicare and a substantial private insurance sector combined with national mechanisms for drug and medical device and other health technology evaluation and drug and health service pricing, provide the levers for maximising health gain from finite resources.

Achieving this goal could be assisted by implementing an analytical framework that uses available information on population health, the determinants of population health and the cost-effectiveness of public health and clinical services for optimising health resource investment, as suggested by Professor John Deeble (1999). Such a framework could, in theory at least, provide a means of rigorously deciding on funding for new technologies and for current technologies. Program Budgeting Marginal Analysis (PBMA) provides one framework for doing this. To date, PBMA has not yet delivered on its potential because it has not yet been comprehensively linked with two other analytical frameworks, namely the Cochrane Collaboration in evidence-based medicine and the Health Goals and Targets framework using mathematical models. While there is some research in this area, we are not aware of any concerted, major research into developing such a framework.

The application of existing and new technology is and will continue to be a major driver of increased costs in the health system. In the interests of economic efficiency, it is desirable to maximise the cost-effectiveness of health interventions. It is also desirable to limit overall health expenditure, particularly publicly funded health expenditure where the total pool of funding for all public services is limited and hotly contested by interest groups. A conflict arises in the introduction of a technology that is relatively cost-effective but leads to an overall increase in expenditure. This could theoretically be managed by retiring less cost-effective technologies, but there has been little if any success in retiring less efficient technology except where the new technology is a substitute. Unless there is substitution, the withdrawal of an inefficient technology will withdraw a service from a needy group.

To contain these cost pressures, public policy would need to manage the introduction of technologies into the Australian health care market, both public and private. Broadly, the current system of control has two stages: The first, operated by the Therapeutic Goods Administration (TGA), examines the safety and efficacy of new technologies (diagnostics, devices, pharmaceuticals, etc) before giving approval for their use in Australia. The second, operating through the Medicare advisory mechanisms and examines the cost-effectiveness of some interventions and makes recommendations on public subsidies for technologies. This was introduced first for pharmaceuticals in relation to the Pharmaceutical Benefits Schedule (Pharmaceutical Benefits Advisory Committee (PBAC)) and has been extended to include clinical procedures for the Medicare Benefits Schedule (Medical Services Advisory Committee (MSAC)).

Australia is one of the world leaders in this kind of pre-subsidy assessment of new medical technologies. Australia introduced controls on access to public subsidies for pharmaceuticals on the basis of cost-effectiveness in 1993 through the PBAC, and on access to public subsidies for medical services on the basis of cost-effectiveness in 1998 through the Medical Benefits Advisory Committee. The PBAC restricts and regularly reviews subsidies to specific pharmaceuticals and to pharmaceuticals for specific medical conditions as a way of influencing doctors to prescribe more cost-effective medications. These mechanisms are recent pathfinding innovations, and experience in their application is limited. As experience grows, their influence on efficient resource use in the health system should grow.

The separation of the two stages controlling the introduction of new technology (that is, safety assessment by TGA and public subsidy assessment by PBAC and MBAC) provides a door through which technologies of low cost-effectiveness can end up being publicly subsidised. This can occur because once a technology has been approved for use in Australia, it may be used in the private sector. This leads to pressure for the technology to be made available in the public sector, supported by public funding. In addition, once a technology is approved by TGA it may be used for clinical indications that were not originally envisioned, used on an expanded range of patients, or used in other ways that do not conform to the circumstances under which approval was initially given (eg drug dosage or regimen). These changes can have significant effects on the cost-effectiveness of the intervention as used. Since cost-effectiveness is increasingly being used as a criterion for public subsidy of an intervention, the current process for approving public subsidy (which is essentially a one-off exercise for each intervention) may be insufficient to ensure continuing value for money.

Other problems can arise following introduction of a new technology due to the split responsibilities for health care funding in Australia's federal system. Technologies which reduce or eliminate hospital stays can shift costs from the States to the Commonwealth, while new high tech treatment technologies for use in hospital can greatly increase costs for the States with little direct burden on the Commonwealth. This has been dealt with on a case-by-case basis for some specific technologies, but illustrates another adverse consequence of the complexity of Australia's health funding arrangements.

There may be no generic answer to this, with each case having to be managed on its merits according to the circumstances at the time, particularly if a technology of low cost-effectiveness but large market potential is discovered and developed in Australia. Perhaps the current Australian system of separate approval for use and

approval for public subsidy is the preferable arrangement, with strong mechanisms for resisting public subsidisation of technologies of low cost-effectiveness.

These issues of technology introduction and pricing are clearly inter-related, and could be addressed by an integrated approach to approval and subsidisation. Such an approach could have the following features, some of which may already be in place in some areas of the technology approval and funding process:

- initial approval of use of a technology in Australia should include consideration of the knock-on cost implications for the public sector of introduction of the technology into the private sector;
- approval should be related to clinical indications and patient group;
- technologies with high aggregate cost to the public (ie, not necessarily high unit cost, but high (unit cost) X (usage) should be subject to periodic review of cost-effectiveness in relation to actual patterns of use, in terms of clinical indications and patient groups to which the technology is applied. This cost-effectiveness information should inform ongoing approvals for the use of technologies according to clinical indication and patient group;
- participation by consumer representatives in the approval and review processes is desirable, for enlisting public support for hard decisions; and
- Australian research on health technology policy issues. The information in this paper was obtained by searching Medline to identify relevant articles, and following up references in these articles. No recent relevant Australian articles were found. This suggests either a lack of research in this area in Australia, or the research not being published in the peer reviewed literature.

Australia has shown leadership in developing these arrangements, particularly in giving cost-effectiveness considerations an important place in public subsidy approval processes. The anticipated expansion of health care technology in the next century underscores the need to maintain and strengthen these mechanisms and to explore ways of retiring less cost-effective technologies for which there may be few alternatives. If this cannot be done, it will be difficult to improve the overall efficiency of the health system and improve total population health, even with rising health expenditures. On the other hand, if it can be achieved, Australia and other nations may be able to keep health expenditures within manageable limits and allow their economies to meet the full range of desirable social objectives, including providing high quality health care to all their people.



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