Productivity Commission Study of
Impacts of Medical Technology in Australia

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Summary:
The problem is clearly stated in the study document:
"…this study is required to consider past and potential future expenditure impacts of medical technologies for both the government and private sectors, and also to assess the benefits of these technologies. In addition, the Commission is asked to identify processes for assessing advances in technology and any gaps in these processes. In short, the study is intended to help inform whether medical technology is being used in a way, and to an extent, that delivers the maximum net benefits to the community."

The solution the authors propose is that:
The use of systems approaches, including dynamic systems simulation of the health sector, is required to illustrate, understand and quantify the net aggregate impacts of medical technologies and assess their benefits. This approach matches key features of the problem:
** Delivering maximum net benefits is confounded by the uncertainty of future uses and risks and benefits;*
** Advancing medical technologies and adopting beneficial uses involves dynamic interactions among system constraints and individual behaviours; and*
** Costs, risks, benefits and their actual and perceived value change over time and are borne unevenly within the community.*

This submission contributes to the debate by introducing an overall dynamic systems approach to the key features of the interaction among medical technologies, health demand, people treated, technology assessment, benefits and costs or expenditure. It also outlines briefly how this can be developed into a systems simulation using newer multi-method and multi-level techniques. Such a simulation can be used to collaborate widely on policies to shape the future impact of technology on costs and value across the entire health system.

Introduction:
"Medical Technology in the Health System" is an area that consists of many complex interventions within a complex system. There are dynamic interactions among demand and supply, price, payment and subsidy incentives, and capacity availability and utilisation.

To investigate this area clearly and accurately requires the right mix of tools and approaches. We have found systems simulation using multi-method approaches useful for policy analysis and evaluation of these "wicked" problems (Sterman 2001).

In particular, systems dynamics (SD) is useful for pattern analysis, whilst combined SD+Agent Based (AB) approaches are more appropriate for geographic and individual technology variability analysis (Borshchev 2004).

Systems simulation provides a logical consistent framework for telling a complicated story clearly and accurately. It can be used as a safe "in silico" workbench to formulate and test policy proposals, including pointing out the disadvantages of non-systemic solutions to complex issues. It uses a mix of qualitative and quantitative methods, and can be used as a collaboration artifact to build consensus among different disciplines and viewpoints. One of the authors has a long experience with simulating health system issues, including medicines use (Heffernan 2004) and the impact of ICT on quality and performance, and is currently working on simulating policy options for the acute aged care interface.

As an illustration of the systems approach, we have developed a set of causal loop diagrams to help represent the dynamic complexity of the Progress Report Overview key points (p. xxvi). These diagrams illustrate statically, the dynamic ebb and flow of forces that are 'slides' of the dynamic and analytical complexities, whereas the computer simulation these diagrams represent is the 'movie', with interactive, dynamic changes clearly identified and communicated over time.

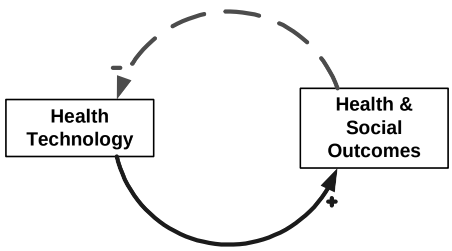
Proposed Methodology:

Building a Systems Simulation to address the Problem Statement:

Causal Loop Diagrams build up an increasingly complex picture and highlight the dynamic feedback interactions. Most people prefer a linear cause-effect approach, such as: *"Health Technology overall improves Health and Social Outcomes"*

This is represented in a causal loop diagram with a positive (blue) arrow. The technical meaning of this in a dynamic sense is that health technology tends to cause health and social benefits to move in the same direction (as health technology increases, health and social benefits increase, as health technology decreases, health and social benefits decrease).

However, in reality, there are also some negative consequences. In the next diagram the negative feedback effect of excessive health expenditure on health technology is represented by a negative (red) loop. This excessive expenditure will eventually limit the use of health technology, that is, the possible may be unaffordable. This feedback interaction is called circular causality or reasoning. Technically speaking it means that there is an opposite effect of health and social outcomes on health technology.

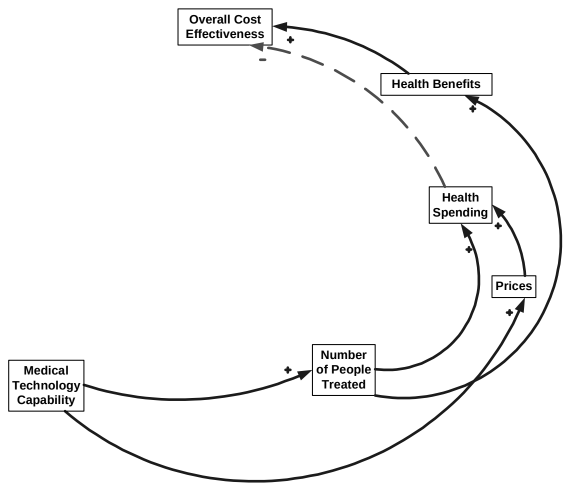


Building a Systems Simulation to address the Progress Report Overview Key Points (p.xxvi of the Progress Report) represented as Causal Loop Diagrams

The following diagrams illustrate this approach for each of the Key Points in succession (the addition of new elements for successive points is represented by outlined boxes)

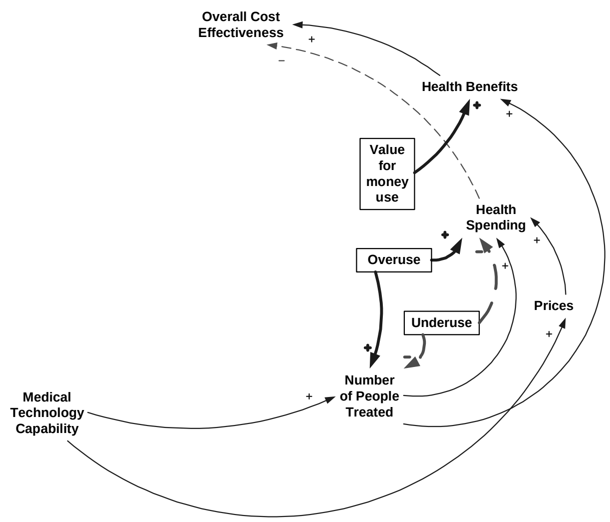
Key Point(1): "Medical technology advances have brought large benefits and driven health spending due to higher prices and number of people treated. The precise impact on overall cost effectiveness of the health system is uncertain …"

Key Point 1 expressed as Causal Loop Diagram (1):



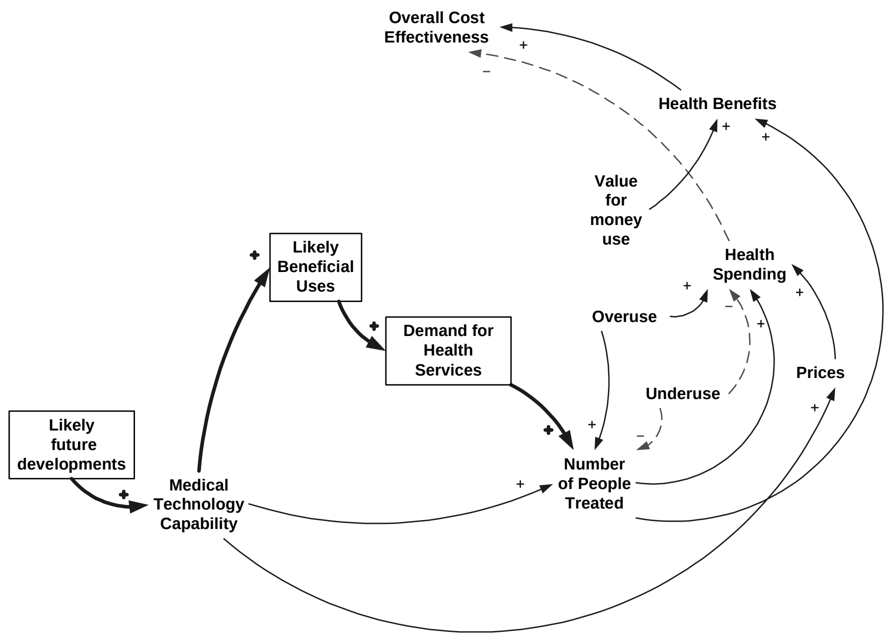
Key Point (2): "Some technology uses appear to provide value for money but there may be room for expanding the use of some technologies and reducing the use of others."

Key Points 1 & 2 combined as build-up Causal Loop Diagram 2:
Note that additional concepts are illustrated as boxed text & their influences as bold arrows in subsequent build-up diagrams.



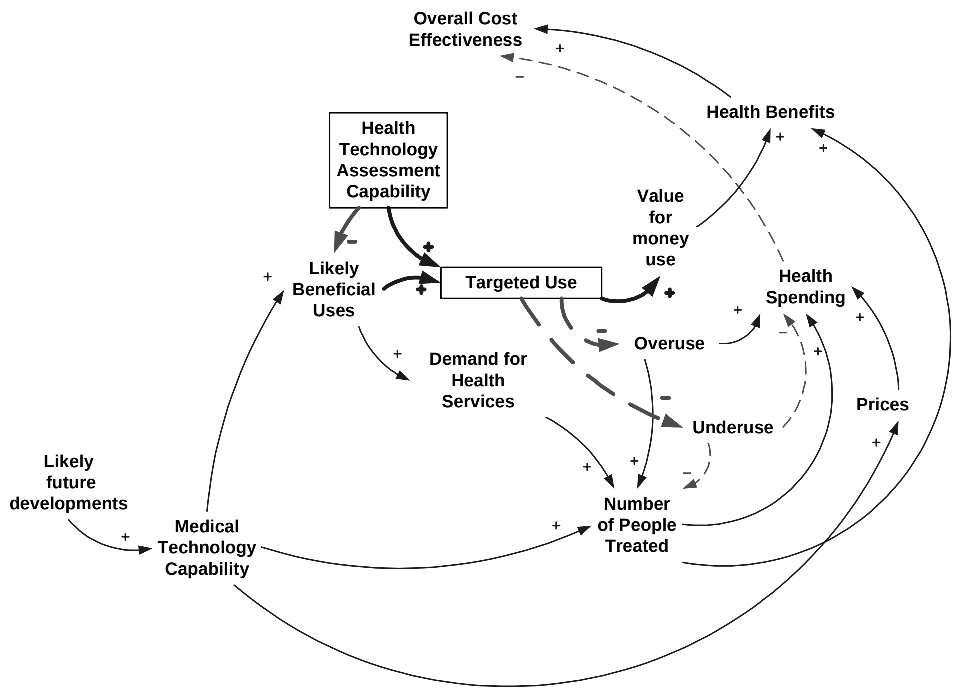
Key Point (3):"Likely future developments and beneficial uses could revolutionise medicine and bring large costs and benefits"

Key Points 1, 2 & 3 combined as build-up Causal Loop Diagram 3:



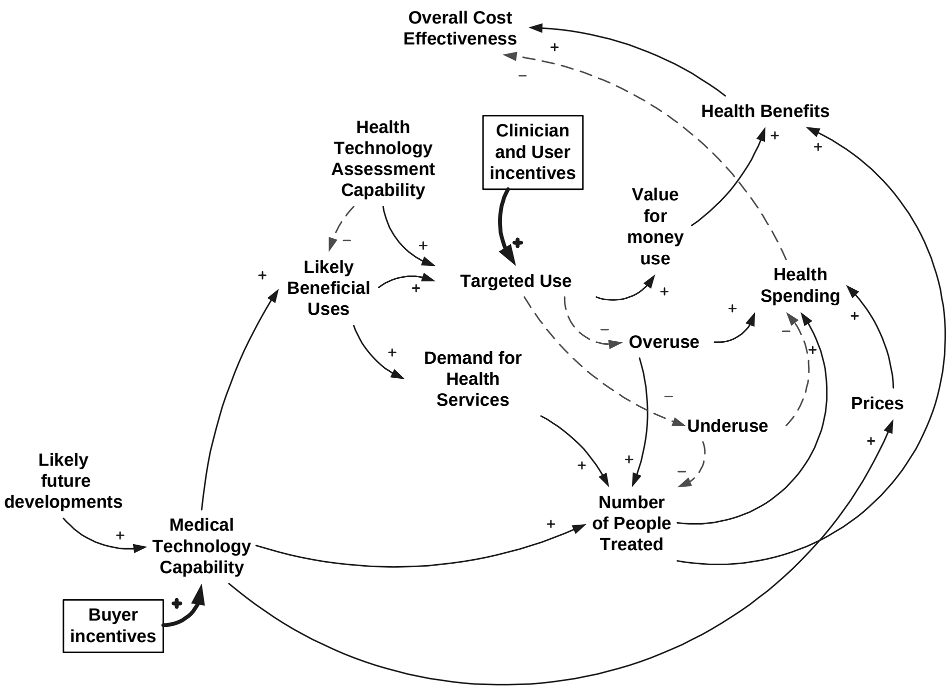
Key Point (4):"Improved Health Technology Assessment processes could help to target new technologies to patient groups likely to benefit most and improve overall cost-effectiveness of healthcare"

Key Points 1, 2, 3 & 4 combined as build-up Causal Loop Diagram 4:



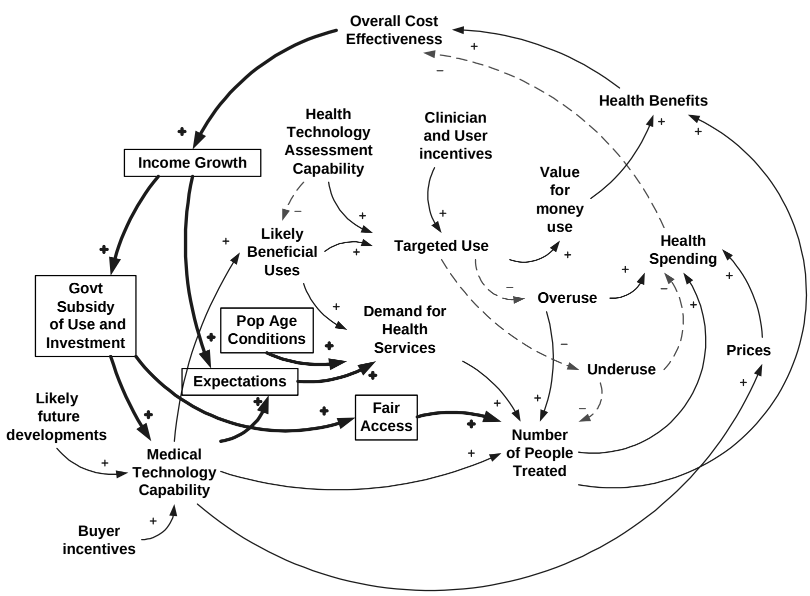
Key Point (5):“ “But appropriate use of technology ultimately depends on the incentives facing users and buyers of technology”

Key Points 1, 2, 3, 4 & 5 combined as build-up Causal Loop Diagram 5:



Key Point (6):“Future advances interacting with increasing demands driven by income growth,...population ageing, subsidised consumer prices and strong community expectations that new technologies should be accessible to all, will put increasing pressures on health”..

Key Points 1, 2, 3, 4, 5 & 6 combined as build-up Causal Loop Diagram 6:



Key Point (7): “The current limited ability of private health funds to influence the uptake of new technologies could place pressure on premiums and Australian Government expenditure via the rebate. Provision of new technologies to privately insured patients in turn will place pressure on public hospitals to adopt these technologies. Differential access to advances in medical technology is likely to be heightened if existing health system arrangements persist.”

Key Points 1, 2, 3, 4, 5, 6 & 7 combined as build-up Causal Loop Diagram 7:

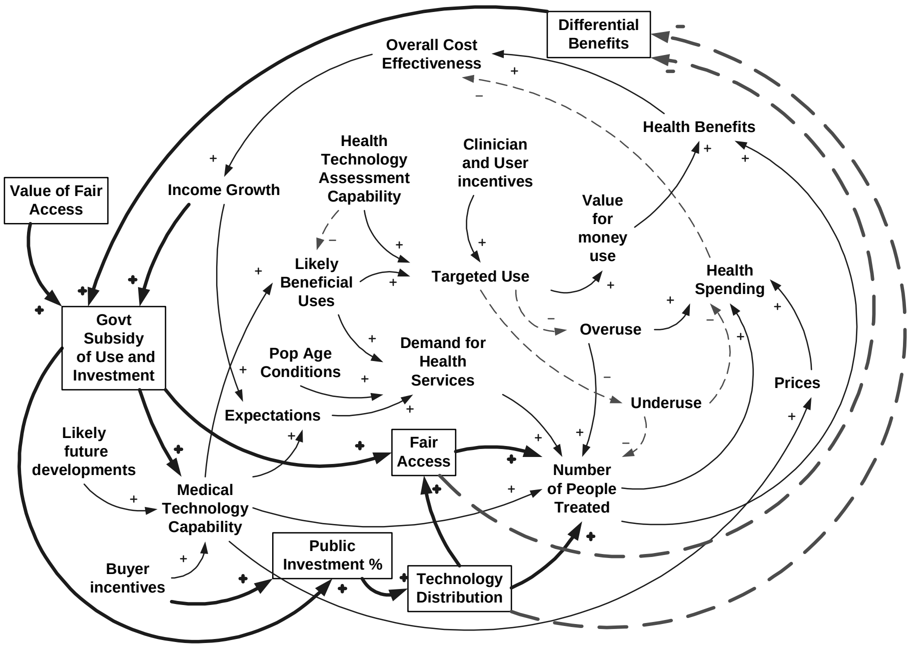
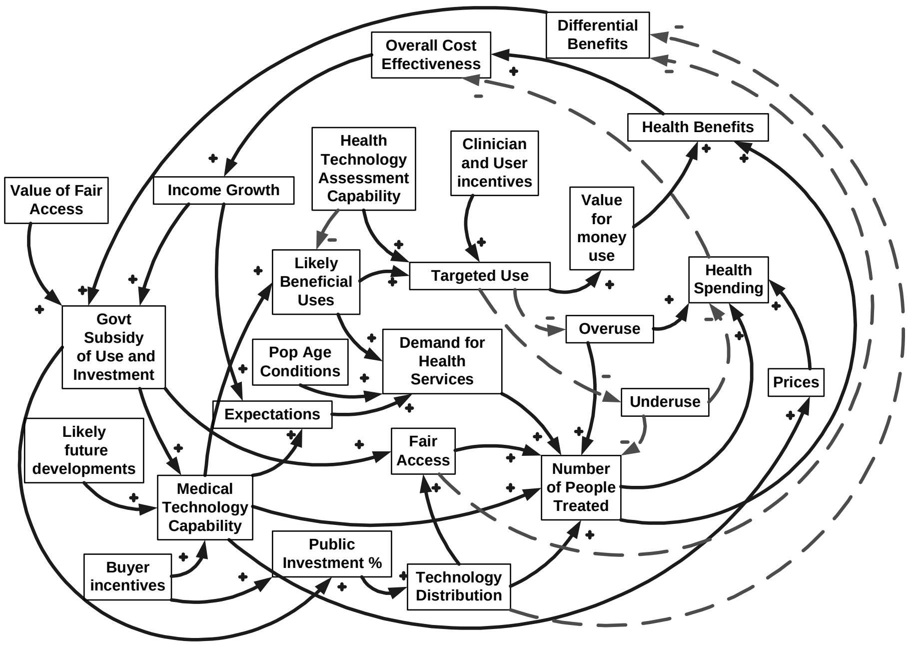


Diagram 8 Final Causal Loop Diagram with all items highlighted:



Developing a Systems Simulation

The causal loop diagram outlines the scope and dynamic interactions to be included in a systems simulation. Some implied context needs to be made explicit, for example, including a population ageing chain and the well-studied dynamics of technology diffusion. This overall aggregate dynamic interaction can be applied to individual technologies, target populations and geographies and simulated through the use of agent-based methods.

The approach used in systems simulation is that of developing insight (theories) based on observation of the real world then testing and improvement of those theories in simulation models (Forrester 2003).

Generic versus Specific Modelling

The complexity of the health system should never be underestimated. Over simplification often results in un-intended consequences. The nonlinear behaviour of complex systems, the presence of competing feedback loops, and the presence of system delays are all part of the resulting complexity.

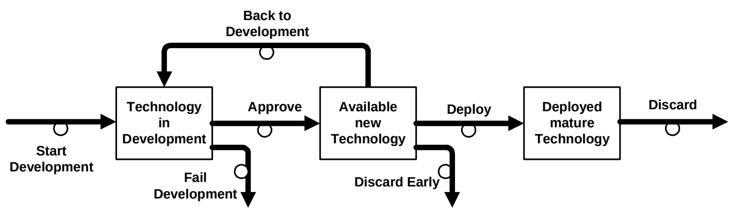
One dilemma faced in modelling complex systems, such as the health system, is the trade-off between generic and specific modelling.

Generic models tend to be larger and more complex. In some cases, many applications might be better handled with a collection of far simpler models. On the other hand, it is important to have a model in which the major modes of behaviour exist simultaneously for examining how the different modes may interact. In a nonlinear model, the superposition theorem does not apply, the different modes do not exist separately, and do not simply superimpose on one another (Forrester 2003).

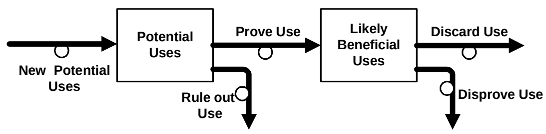
Hence, an initial simulation should focus on developing a generic model. After a larger system is understood, simpler special-purpose models can be developed using data-rich examples. These could be developed as case-study examples for particular technologies, with a classification (see below) that supports recognition of the dynamic technology life-cycle characteristics of development, adoption and widespread use followed by obsolescence.

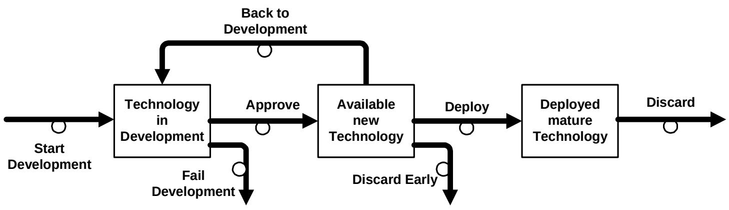
Distinguishing between Stocks (Levels) and Flows (Rates)

Technology life cycles of development, deployment and obsolescence can be represented as a chain of stocks and flows

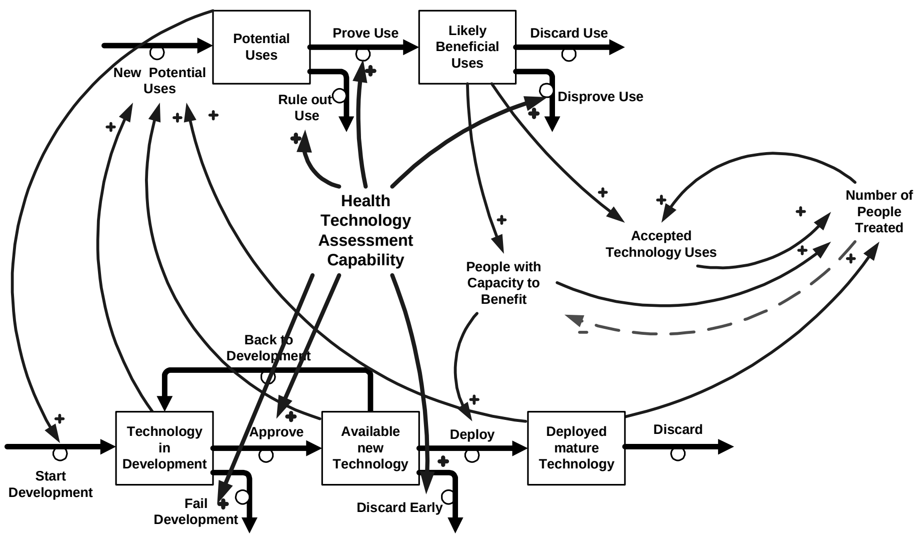


We can similarly represent the (uncertain) benefits of new technology usage, which progresses over time as more experimentation and evidence (e.g., proof of net benefits) accumulates, as an additional chain of stocks and flows of technology use.





These two chains of technologies and technology uses have interlinking feedback effects which also link with key concepts in our previous causal loop diagrams:



This also shows the central importance of Health Technology Assessment in potentially influencing the flows of technology and uses at multiple points in their life cycle.
It should also be noted that the concept of substitution technology use is easily distinguished from complementary technologies in this notation. For a substitution technology an inflow of a new proven likely beneficial use is associated with an outflow of a discarded use from this same stock. This linkage between inflow of likely beneficial use and outflow of discarded use is not present with complementary technologies.

Classification of technologies

In order to understand the impact of different technologies on the health system from a demand and supply perspective, and the impact on health outcomes, a classification framework is needed. We propose the use of a multi-dimensional framework classifying personal health technologies into three main categories based on the purpose of use:

1. Diagnosis
2. Prevention
3. Treatment (life saving or life enhancing)

In addition there are two other proposed categories of health technology which will be handled separately from personal health technologies:

4. Clinical and administrative support systems. The focus for these systems will be on their effect on the level of uncertainty and information asymmetry in the decision process.
5. Technologies used for non-personal population and public health intervention and infrastructure. These also have significant effects on health status.

Individual case studies *should* explore:

· Examples of **under-use, overuse and misuse** of a technology because the benefits or costs it creates elsewhere in the system, or over time, are not taken into account by decision makers

· The **behaviour of decision makers** across areas of the system funded or subsidized by the Australian Government — for example, pharmaceuticals, medical devices — and/or areas funded primarily by State and Territory governments, such as public hospitals versus private hospitals should be investigated.

Future Policy Challenges

The authors agree with the Productivity Commission (Section 10.2) that there is a substantial body of analysis which could be 'work-in-progress' in the future.

The Commissions preliminary conclusions recognise that the costs and benefits of medical technology are interactive with a large number of factors such as demand drivers (ageing, income growth and community expectations) and policies (access modifiers, public versus private insurance and investment incentives, short-term budget planning etc). These conceptual interactions are not well represented by reporting text in documents but can be readily symbolized by the proposed Systems Simulation approach which can be used to analyse the Areas of Further Work (Section 10.3). We commend that the Productivity Commission intends to develop and extend analysis into these further areas.

It is noted that the central issue apparent in development of an effective and efficient healthcare system is not the cost-benefit of medical technology equipment per se but the cost-benefit of its interventional use in improving health. In this respect the use of systems simulation to 'see' and 'play out' the interactions of system constraints, clinician practices and consumer behaviours can be used to test the impacts of policies intended to limit or promote medical technology interventions. The dynamic view of the context of cost-benefit assessment remains crucial, and is well expressed in the following quote:

"Of course, shifting the direction of innovative activity and increasing efforts to assess the benefits and costs of new and existing technologies is not going to matter unless the results of these assessments are integrated into clinical decision making. The way in which a new technology ultimately will affect costs depends on the manner in which it is incorporated into the larger system of medical care-how the profession chooses to use it and to modify it. In addition to their role in developing new medical interventions (often in collaboration with industrial firms), physician innovators tend to find new patient indications for existing interventions.

Although some of these new clinical uses may well be cost-effective, we suspect that the broadening of indications ultimately leads to marginally beneficial applications that raise overall spending levels. An important policy challenge in the years ahead is to tie the results of assessments more strongly to clinical decisions, either directly (through feedback to the clinical community) or indirectly by integrating them with regulatory or reimbursement mechanisms. Ultimately, even the most sophisticated techniques of technology assessment are of little operational significance unless they provide a basis for restricting expenditures on medical interventions that are of minor social benefit." (Gelijns 1994)

Conclusion:

The Commission's Progress Report contains supporting information and evidence for the need to assess the costs and benefits of medical technology interventions in the Australian healthcare system. The Report's preliminary conclusions confirm that the costs and benefits of medical technology depend on the complex interaction of a large number of factors such as demand drivers (ageing, income growth and community expectations) and policies (access modifiers, public versus private insurance incentives, short-term budget planning etc). These conceptual interactions are not well represented by reporting text in documents but can be readily symbolized by the proposed Systems Simulation approach, which can be used to analyse the Areas of Further Work (Section 10.3).

We believe that a whole systems simulation approach is the most suitable way to further test health policies related to the dynamic interactions of medical technologies, ageing, health insurance, the pharmaceutical industry (all of which have been the subject of separate Commission reports), and other health determinants.

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Authors Footnote: *Current file ["PCMT Submission Final_BW June05 (McDonnell_Tipper)"] created 10 June 2005 supplementary to submission 31 May 05 Word document as web publication of that submission rendered arrows black & white in .pdf ; now replaced by dotted lines for Red (-'ve) effectors in diagrams.*