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Population ageing and health outlays: assessing the impact in Australia during the next 40 years

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AUTHOR NOTE

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GENERAL CAVEAT

NATSEM research findings are generally based on estimated characteristics of the population. Such estimates are usually derived from the application of microsimulation modelling techniques to microdata based on sample surveys.

These estimates may be different from the actual characteristics of the population because of sampling and nonsampling errors in the microdata and because of the assumptions underlying the modelling techniques.

The microdata do not contain any information that enables identification of the individuals or families to which they refer.

ABSTRACT

The ageing of the population in Australia, due to decreased fertility and increased longevity, is placing increased pressure on government budgets. This fiscal pressure is heightened by the large cohort of baby boomers reaching older ages. The magnitude of this demographic shift has prompted several major government reports within Australia on the likely fiscal impacts and policy challenges associated with population ageing. A key concern is the high level of public expenditure on older Australians — particularly in the areas of social security, health and aged care — and how these costs are going to be financed. In Australia, the development of APPSIM, a dynamic microsimulation model, has been funded by 12 government agencies to develop a sophisticated policy decision making tool to look at the effects of ageing over the next 40 years. This paper describes the development of the health module within APPSIM. The module has been developed to consider the effects of changing health status, as well as the effects of ageing, on health outlays by the Australian government over the next 40 years. Illustrative examples of the output from the APPSIM health module will be presented, showing the changing levels of health expenditure and the distributional effects of this government outlay in Australia.

Keywords: APPSIM, health care projections, health expenditure, health service utilisation, dynamic microsimulation, population ageing

ABBREVIATIONS

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of health and Welfare
ALOS	Average length of stay
APPSIM	Australian Population and Policy Simulation Model
CURF	Confidentialised Unit Record File
DMSM	Dynamic Microsimulation Model
GDP	Gross Domestic Product
GP	General Practitioner
HES	Household Expenditure Survey
HILDA	Household, Income and Labour Dynamics in Australia
IGR	Intergenerational report
MBS	Medical Benefits Scheme
MSM	Microsimulation models
NATSEM	National Centre of Social and Economic Modelling
NHS	National Health Survey
NPD	Non-private dwelling
PBS	Pharmaceutical Benefits Scheme
PHI	Private Health Insurance
PHIAC	Private Health Insurance Administration Council
SAHS	Self-assessed Health Status
SIH	Survey of Income and Housing

INTRODUCTION

Increased longevity and decreased fertility has seen greater numbers of the population aged 65 years and over. Associated with these phenomena has been a decrease in the proportion of the working-age population. A consequence of these ongoing demographic shifts is an increased pressure placed on government budgets, due to slower growth in the labour force and the economy, combined with increased expenditure on pensions, aged care and health care. This leads to questions about how these increased costs will be funded. Public policy will need to be developed to control the costs to government. Such policy may result in increasing out-of-pocket payments by the individual for health care and aged care. However, two of the key aims of health care are affordability and equity of access, which increasing out-of-pocket payments may jeopardise. The development of the health module for APPSIM has occurred within this context, aiming to place issues of health and health care expense within the framework of wider social and economic issues.

AN AGEING AUSTRALIA

In the last 20 years the number and proportion of persons aged 65 years and over has increased substantially. In 2007 there were almost 2.8 million Australians aged 65 years and over, up from just over 1.7 million in 1987(ABS 2008). The percentage of Australians aged 65 years and over had grown from 9.1 per cent in 1987 to 13.2 per cent in 2007 (ABS 2008). From 2011 onwards the very large baby boom cohort will begin to reach 65 years, leading to a further dramatic increase over the next 40 years in both the number and proportion of the Australian population aged 65 years and over.

Above and beyond the increasing size and proportion of the older Australian population, it is also how the population ages that will influence the extent of budgetary pressure experienced due to the increasing number of older Australians. There have been three key scenarios with respect to the health of the ageing population that have been put forward. Firstly, there is *compression of morbidity* (Fries 1980) where, whilst the older population lives for longer, individuals will remain healthy until the time just prior to death. In contrast, the *expansion of morbidity* view proposed that, whilst living for longer, individuals will spend those extra years in poor health suffering from chronic disease (Kramer 1980). Between these two extreme scenarios lies a concept of "dynamic equilibrium", in which the years in disability lived are longer but the disability is less severe (Manton 1982). More recently, it has been proposed that the trends described may differ between the old population and the oldest-old population - and that there is a cyclic effect between compression and expansion of morbidity dependent on the stage of ageing present within the population (Robine and Michel 2004). Compression of morbidity would see a possible dampening of the effects of ageing on health services required and consequent health expenditure. In contrast, expansion of morbidity would see greater pressures being placed on health budgets. Further, issues such as availability of new technologies and medical practice with respect to service provision will mediate the effects of ageing on health service usage and health expenditure.

In Australia there has been a steady growth in government spending on health care since the 1990's. To allow forward planning so the government is well placed to face emerging issues, projections, particularly of health expenditure, are vitally important. In Australia, the main reports to provide projections of future health expenditure within the context of government policy are the Intergenerational Reports (Treasury 2002, 2007) and the Productivity Commission report on the impact of ageing (2005). The Intergenerational Report (IGR) looked solely at the potential outlays of the Australian Government, whilst the Productivity Commission report considered outlays by both the Australian Commonwealth Government and State and Territory Governments. Neither report considered the possible out-of-pocket costs that may be incurred privately by the Australian population over time.

Each report has provided separate projections for the various sectors of the health system: hospital, medical services, pharmaceutical and other health. The Productivity Commission included private health insurance rebates as part of the "other health" (2005), whilst the Treasury report modelled the private health insurance rebate separately (2007). The same basic cell-based method has been used in both reports. The age-sex profile of expenditure was taken and combined with the projected population and changes in the per capita costs (i.e. the non-demographic growth rate[1]). Within the reports, non-demographic growth rates have been applied differently. In the Treasury report, non-demographic growth rates were modelled separately for all the health sectors being considered, based on historical data (2007). In contrast, the Productivity Commission applied the same growth rate for hospital, medical and "other health" sectors, as they claim that for long term forecasting the historic differences in growth between sectors may not be maintained (2005). To better reflect the linkage between health expenditure and economy-wide growth, the Productivity Commission, applied the growth rates as a premium above growth in GDP (2005), whilst the IGR used stand alone values for the growth rates (Treasury 2007). To reflect the body of research that indicates that there is a dramatic increase in health expenditure within the hospital sector in the last year of life, there has been a separate cost associated with year of death in the hospital sector (Productivity Commission 2005; Treasury 2007).

Within the non-demographic growth rates there are many aspects that drive increasing health expenditure which are being implicitly modelled. These aspects include: introduction of technology; increased demand by consumers; changing patterns of demand; and excess health inflation. This type of modelling does not allow separate consideration of the various aspects underlying non-demographic growth in health expenditure. Modelling by Begg at al (2008) of health expenditure included the explicit projection of changing chronic conditions and illnesses. This model went beyond government expenditure and also looked at private expenditure. However, it did not cover the total health expenditure within Australia, as the expenditure captured was only that attributable to the specific conditions being modelled.

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[1] Non-demographic growth rate is the increase in per person costs that where not attributable to changes in age structure or population.

The types of models discussed above only allow consideration of expenditure within the cell-groups included in the model. Such models do not allow policy makers to gain an understanding of who will benefit from government health spending or who may be able to afford to make greater out-of-pocket contributions towards their health care. In addition, the two government reports do not allow explicit modelling of possible changes in health condition risk factors and the potential improvements in health and shifts in health spending by the government, so as to gain a greater understanding of how the different non-demographic factors affect potential future health expenditure.

Each of these models can be considered to provide a "needs-based" indication of future health expenditure. They do not provide an indication of how health expenditure may evolve in the future under different policy options, such as user-pays for health services or restriction of government provision of new technology. Future health expenditure is highly reliant on government policy, and the ability to apply policy in a simulation to gain an understanding of which sections of the population would be most affected is important in informing such policy debate. Microsimulation models offer the ability to apply government policy and gain an understanding of the sections of the population most affected by such policy.

AUSTRALIAN HEALTH SYSTEM

The Australian health system is a complex one involving both public and private service providers, as well as various funding mechanisms. Funding for health is provided by all levels of government within Australia, as well as private health insurers and individual Australians. Government funding can either be direct or indirect (in the form of subsidies or rebates). Almost 70 per cent of total health expenditure is funded by government, with the Australian government contributing almost two-thirds of all government funding (AIHW 2008a).

The Australian Commonwealth government directly funds Medicare which includes the Medical Benefits Scheme (MBS) and Pharmaceutical Benefits Scheme (PBS). Medical practitioner services, optometry, diagnostic imaging and pathology are subsidised under Medicare funding. The PBS provides subsidies for a wide range of pharmaceuticals to provide "affordable access to necessary and cost-effective medicines" (Commonwealth Dept of Health and Aged Care 2000, p. 9). The PBS requires that individuals contribute an out-of-pocket payment towards these services.

In addition to these two key schemes, the Commonwealth government also funds:

- public hospital services, through special purpose payments to the State Governments;
- the 30 per cent rebate on the cost of private health insurance;
- other areas such as medical research and public health; and health services to veterans (AIHW 2008b).

Public hospital services are jointly funded by the Australian and state governments.

Individuals, beyond the coverage they receive from Medicare, may chose to purchase private health insurance. Private health insurance in Australia both duplicates and extends the health insurance available as part of Medicare. The Australian government encourages uptake of private health insurance coverage through several policies: the 30 per cent rebate scheme, lifetime health cover and a one percent Medicare levy surcharge for higher income earners. From 2005, higher rebates for having private health insurance were introduced for older Australians. These incentives and penalties have seen marked increases in private health insurance from the lowest levels in 1998 of 30 per cent. In 2008, approximately 44 per cent of the Australian population had basic hospital cover (PHIAC 2009).

Hospital insurance covers services provided in private hospitals as well as services provided to private patients in public hospitals. In addition, general treatment (formally known as ancillary care) insurance covers allied health and other professional services (AIHW 2008a).

Over the last decade, the growth rate in total expenditure has far outstripped growth in Australia's GDP. The average annual growth rate for health expenditure was of 4.9 per cent, compared to 3.6 per cent for GDP. Between 1996-97 and 2006-07, total health expenditure increased from $42 billion to $94 billion. Government funding was $64.5 billion in 2006-07, with a real growth rate per year of 5.2 per cent over the last 10 years (AIHW 2008b).

In 2006-07, individuals met 17 per cent ($16.3 billion) of total health expenditure, whilst private health insurance covered 7.3 per cent ($6.8 billion) of total health expenditure. Average out-of-pocket expenditure has grown by 3.9 per cent per year over the last decade. Most of the out-of-pocket expenses to the individual are from dental services (23.6 per cent), medications not funded by PBS (26.1 per cent), aids and appliances (13.8 per cent), medical services (12.3 per cent) and other health practitioners (10.6 per cent). The key areas private health insurance funds are private hospitals (48.2 per cent), dental services (12 per cent) and medical services (10.2 per cent) (AIHW 2008b).

Recurrent health expenditure was $87.3 billion in 2006-07, with 30.9 per cent for public hospital services, 19.1 per cent for medical services and 13.7 per cent for medications. Overall, in the last decade recurrent expenditure has grown by 4.7 per cent a year, with the highest contribution from public hospital services (38.9 per cent) (AIHW 2008b).

In this environment of an ageing population and increasing health care expenditure, policy makers are going to be forced to make difficult decisions about health funding, about the balance between government and consumer contributions to health care costs and about the level of taxation, which funds public health outlays. At the same time, there is a need to maintain social equity and access to essential health services for those in need of care.

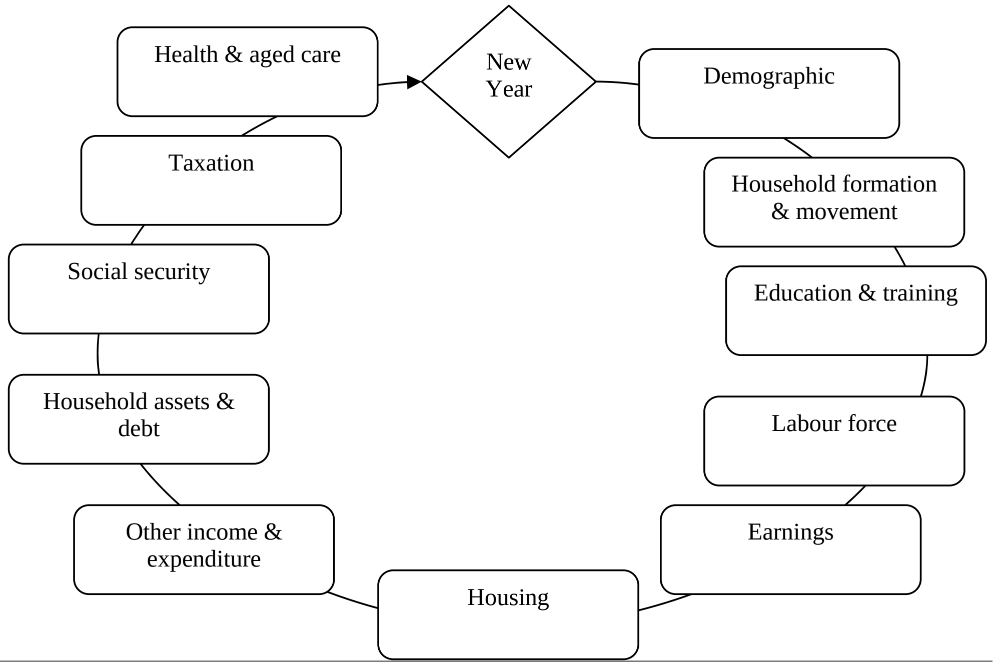
APPSIM

The development of the first version of the Australian Population and Policy Simulation Model (APPSIM), being undertaken by NATSEM, is close to completion. This project has involved twelve government partners as well as the Australian Research Council, with the primary objective of having a fully functional prototype version of APPSIM available to be used to assess the future distributional and revenue consequences of government tax and expenditure programs by end 2009 (Harding 2007).

The model is a closed, stochastic, cross-sectional, dynamic, population microsimulation model that will provide snapshots of the population characteristics and government programs as at 30 June each year from 2001 through to 2050. The model basefile is the publically released confidentialised one per cent unit record file from the 2001 Census. Thus, the model has approximately 188,000 records, with each record having a weight of 100. The population from both private and non-private dwellings is included. The model functions on one year time units, using discrete time functions in preference to continuous time (Harding 2007).

Ultimately, APPSIM will include modules for the modelling of demographics, family formation and dissolution, migration, education, labour force status, earnings, taxation, wealth, housing, health and health care usage, disability and aged-care utilisation, social security and the retirement decision (Kelly 2007a). The construction and order that the modules will be processed within APPSIM is illustrated in Figure 1. To date, significant progress has been made on the demographic, household formation and movement, education and training, labour force and earnings modules. Early versions of the wealth and housing modules have been developed and APPSIM output has been successfully linked to the STINMOD model (which simulates Australia's income tax and social security system(Lloyd 2007)). Ultimately, APPSIM provides the basefile for, and framework within, which the health module is being developed. As a consequence, this health modelling effort is constrained by earlier decisions made with respect to APPSIM and other modules that are already under development.

Figure 1 An overview of APPSIM



HEALTH MODULE FOR APPSIM

Most models used to consider the effects of ageing in Australia have used cell-based projection. These models have provided important lessons for the development of a dynamic health module within APPSIM. Firstly, it was clear that the sectors within the health system (that is, medical, hospital and pharmaceutical) needed to be modelled separately to allow the development of different growth patterns over time. Within the hospital sector it was important to account for the additional costs associated with the year prior to death, as research has shown that there is substantial increases in the cost of hospitalisation just prior to death (Seshamania and Gray 2004; Polder et al. 2006; Werblow et al. 2007). Health costs have grown at rates greater than general inflation (AIHW 2008b), so such a factor needs to be included within the model to account for the excess health care inflation. Finally, the costs to the individual also need to be considered as part of the projection of health expenditure and analysis of redistributive impacts and lifetime costs/subsidies received.

Microsimulation models offer the ability to apply government policy and gain an understanding of the sections of the population most affected by such policy, through being able to include more of the heterogeneity of the population. However, microsimulation modelling of health is relatively recent compared to more established tax and social security policy modelling. As such, there is less precedent for the structure and methods to use when considering a large scale dynamic health modelling within the context of the wider economy. Modelling of health within the large general purpose, socioeconomic based microsimulation models, which aim to investigate general economy wide issues, tend to include health purely as a covariate to be used within the wider context of issues such as labour force participation, the retirement decision and social security (for examples see Gupta and Harding (2007)). Consequently, disability measures are often used due to the direct links to activities of daily living. Thus, poor health represents the inability to stay in the labour force and associated loss of economic productivity, as well as the need for care and ultimately formal services. In reality, disability is at the extreme end of the spectrum that can be considered within health. The Productivity Commission (2005) noted that with respect to health expenditure the presence or absence of chronic illness with or without disability would be a better indicator of future health care costs. They reasoned that even without disability, those with chronic illness, though not necessarily life-threatening, would use more health services than those with no chronic illness. There are few examples in these general purpose dynamic microsimulation models where issues such as health service usage and health expenditure have been modelled. Primarily this is because few of these models have a primary aim of projecting population health and the associated health services and costs. Detailed reviews of the literature surrounding the modelling of health in general dynamic microsimulation models (hereafter DMSMs) have been provided elsewhere (see for example Lymer (2009) or Spielaurer (2007)).

There is no consensus amongst the general DMSMs with regard to the aspects of health to include within the model. The health system is large and complex with many possible elements to be included in the modelling. Some elements of health that have been modelled within a microsimulation model include: health risk factors, health conditions, health status, disability, health service usage, health expenditure, and links between health status and mortality. Whilst these are all important elements of the health system, resources and data limit the inclusion of all elements in a single model. Beyond these elements, private health insurance is an important part of the Australian health system that influences both amounts of services used and cost of those services. However, private health insurance has not been modelled in a general DMSM previously.

Aside from general DMSMs, there are health specific DMSMs, which look at a particular area of health in more detail than is possible in the general DMSMs. These models are focussed on specific diseases such as cardiovascular disease (Mui 1999) and cancer (Houle and Berthelot 1997), specific sub-populations such as those aged 65 years and over (Goldman et al. 2004) or specific policy issues such as private health insurance (Gruber 2000; Blumberg et al. 2003; Garrett et al. 2008). Whilst these models provide indications of how to tackle specific areas that will be included in the APPSIM health module, they are too detailed to replicate in a general DMSM.

From reviewing the literature, it is evident that the modelling of health is based on two factors. Firstly, it is the aspects of health that are directly relevant to the aims of the model that are included. Secondly, the level of complexity of modelling is limited by the availability of data within the country for which the model is being developed. Consequently, when considering how health should be modelled for APSSIM, the aims of APPSIM in relation to health had to be clearly defined and a review of available data was required. Finally, it is clear that building a flexible framework for the health module so that additional aspects of health can be included at a later stage is vital to a successful outcome.

AIMS AND OBJECTIVES

Following on from the lessons of earlier models, clear aims and objectives needed to be defined.

The aims of the health module within APPSIM were firstly to build **modelling infrastructure** to assess the distributional impact of changes in health status and health policy over the next 40 years; and secondly, to investigate the effects of changing **health patterns** in the **ageing** Australian population and the effect these changes have on **health expenditure**, both by the government and the individual.

Consequently, the objectives of the modelling effort were split into model building objectives and analysis capacity objectives. With respect to model building, the key objective was the development of 4 sub-modules to make up the initial health module for APPSIM, with the four sub-modules being:

- Health status;
- Private health insurance;
- Health service utilisation; and
- Health care expenditure.

The detail and complexity with which these sub-modules can be developed are limited by data availability and data quality.

The objective with respect to analysis is to evaluate the effects of changing health status profiles on healthy life years lived and life-time health expenditure by the government and the individual, through distributional analysis looking at socioeconomic status differentials.

DATA SOURCES

APPSIM has the publicly released confidentialised one per cent unit record file from the 2001 Australian census as its basefile. This contains records for about 188,000 persons in about 75,500 households. Whilst this basefile does not include any specific health variables, the large sample size that it offers was seen as a major advantage in the building of APPSIM (Cassells et al. 2006; Kelly 2007b). Each person in the basefile has a weight of 100 and there are records for persons both in private and non-private dwellings (such as nursing homes). Due to the lack of readily available health data on the basefile, all variables in the health module need to first be imputed onto the basefile, and then transitioned across time.

One of the key advantages of microsimulation is that it allows the combination of a range of data from various sources. In the construction of APPSIM's health module, this aspect of microsimulation is drawn on heavily. Australia has no single data source that supplies all the data required to complete the modelling anticipated for APPSIM's health module. A summary of the various data sources that are proposed to be used and the sub-modules they inform is presented in Table 1.

In Australia, whilst there is a comprehensive national health survey, this is a cross-sectional survey with no longitudinal information to inform the transition probabilities required of a DMSM. Available longitudinal health data in Australia has generally been collected for specific sub-populations, such as the Australian Longitudinal Survey of Ageing which collected data from persons aged 70 years and over living in South Australia (Luszcz et al. 2007) or the Dubbo Study (again a survey focused on the older population of a country town in New South Wales) (Simons et al. 1990). Alternately, in Australia there is the Household Income and Labour Dynamics (HILDA) survey, a general population survey focused on income and labour force, but a survey which does include some health data. The health data collected across all waves of the survey is the SF-36, a questionnaire to establish seven domains of health. Some information about health risk factors has been asked across all waves of the survey, such as smoking status, alcohol consumption and physical activity levels. Indicators of obesity have only been collected since 2006. Specific questions about health service usage (namely hospital admissions) and private health insurance have only been asked in the fourth wave (Watson 2009) .

There is administrative data available about the use of health services covered under Medicare and their associated costs. Whilst this gives aggregate information and some age-sex data, it does not provide data about the socio-economic circumstances of the service recipients. Whilst this data gives a distribution of the number of services per person being used in a 12 month period, it does not link across years to indicate the 'year on year' usage of an individual.

For hospitals there is administrative data available that indicates the aggregate number of hospital separations[2] and has some information about the individual (such as age, sex and residence), but does not include income data. Some Australian jurisdictions match records to allow an indication of the number of separations per year of an individual. Only by special request is matching across years to determine year on year separations of the individual available.

[2] A hospital separation refers to the completion of an episode of admitted patient care. A separation may be the whole length of hospital stay or a proportion of the stay beginning and ending with a change in the type of care (AIHW 2008a). In contrast, a hospital admission only occurs at the time of entering hospital. By definition, there maybe multiple separations within one hospital admission.

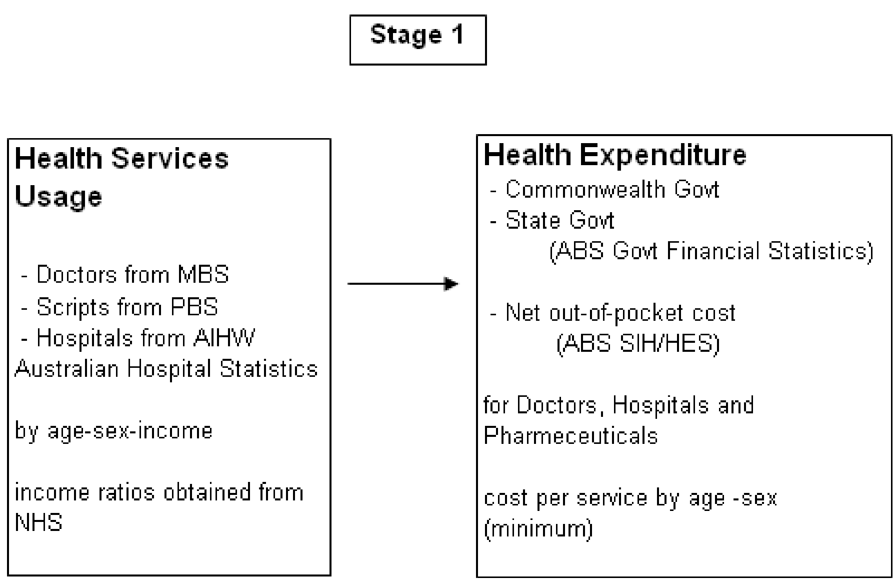
Table 1 Data sources for modelling the APPSIM health module

Module component	Data source
Health service usage	
1. Medical	Medicare Australia administrative data
2. Hospitals	AIHW hospital data cubes; ABS NHS 2001
3. Pharmaceuticals	Medicare Australia administrative data
Health expenditure	
1. Government:	
Medical	Medicare Australia administrative data
Hospitals	AIHW health expenditure data cubes
Pharmaceuticals	Medicare Australia administrative data
2. Individual	ABS household expenditure survey
Health status (5 levels)	
1. 2001 baseline imputation	ABS NHS 2001
2. Annual transitions	HILDA
Private health insurance status (yes/no)	
1. 2001 baseline imputation	ABS NHS 2001
2. Annual transitions	HILDA

STRUCTURE OF APPSIM'S HEALTH MODULE

The initial sub-modules that have commenced development are the health service usage and health care expenditure modules, as illustrated in Figure 2.

Figure 2 Stage one of health module development



The health services and health expenditure sub-modules separately model the health sectors: medical, hospital and pharmaceutical. The focus of the modelling is on the population aged 15 years and over living in the community. Children and residents of non-private dwellings (that is living in nursing homes and the like) are special populations that require separate modelling and often the readily available data does not adequately represent these populations. For example, the ABS National Health Survey does not include persons living in non-private dwellings and does not ask about the self-assessed health of children nor the private health insurance coverage a family provides for its children (ABS 2003). In this prototype health module, data for children and those living in NPDs will be included based on age-sex averages available in administrative data. The administrative data includes these sub-populations within their scope. However, in later more detailed modelling, the data required for these sub-populations is inadequate. Consequently, the later stages of modelling that are planned are focused on adults living in the community.

For each of the sectors, the initial application of the model is a *steady-state*. That is, the conditions present in 2001 (the APPSIM base year) will be assumed to continue throughout the projection period. This will form a base line to consider the reliability of later projections that include factors for health care inflation and changing health status across the time period.

Currently, the *medical sector* is defined as the services provided under MBS. It includes not only services provided by a doctor, both GPs and specialists, but also other services such as pathology, imaging and optical. This allows us to use the Medicare administrative data to determine the average number of services used annually per person by age-sex groups (see Table 2). This was initially determined for 2001 and imputed onto the APPSIM basefile.

Table 2 Average annual number of MBS services per person by age and sex, Australia 2001

Age Group (in years)	Male	Female
0-4	7.96	7.25
5-14	4.47	4.43
15-24	4.69	9.13
25-34	5.48	12.92
35-44	7.09	12.33
45-54	9.83	14.42
55-64	14.91	18.15
65-74	23.05	23.13
75-84	21.81	25.99
85 and over	19.61	25.19

Source: Calculation using Medicare Australia (2009a) data

The average cost of an MBS service by age-sex group was determined for 2001 (as presented in Table 3). This was applied to the APPSIM basefile as a unit cost. Thus the total cost per person was the number of MBS services used multiplied by the average cost per service.

Table 3 Average cost to Commonwealth government per MBS service by age and sex, Australia 2001 ($)

Age Group (in years)	Male	Female
0-4	30.17	29.33
5-14	31.60	30.08
15-24	33.91	30.82
25-34	34.53	34.15
35-44	35.77	36.82
45-54	37.13	37.15
55-64	38.35	37.17
65-74	38.39	36.64
75-84	37.88	36.90
85 and over	36.01	34.88

Source: Calculation using Medicare Australia (2009a) data

At this stage the medical costs only reflect the costs to the Australian Commonwealth government. It is anticipated that at a later stage the out-of-pocket costs to the individual will also be included. One of the major difficulties in including private cost to the individual is the availability of data. Whilst the cost of services is collected by Medicare Australia, such cost data is not readily available in the public domain. Other data sources that give some indication of out-of-pocket costs are the HILDA survey and the ABS Household Expenditure Survey (HES), which both collect information about costs to the household of medical care from a representative sample of the Australian population living in the community. Whilst the Medicare Australia data would supply an out-of-pocket cost for each service, HILDA and HES surveys provide an estimate of the out-of-pocket cost for the family. Currently a data request is being processed for the Medicare Australia data. However, in the interim, investigation of other possible data sources is being carried out.

The *pharmaceutical sector* is currently represented by medications covered under the PBS (that is, this is a subset of all medications). Using this definition allows the use of Medicare Australia administrative data on the supply and cost of scripts to inform the modelling. The estimated average number of PBS scripts per person by age-sex group for 2001 was determined (see table 4). The actual 2001 age-sex distribution of supply of scripts is not readily available. Consequently, for this initial specification of the model, data previously supplied by Medicare Australia to NATSEM for another project that gave the age-sex distribution for the financial year 2002-03 was applied to the 2001 aggregate number of scripts to provide an estimate of the age-sex breakdown of scripts in 2001. This breakdown was then applied to the APPSIM basefile.

Table 4 Estimated annual average number of PBS scripts per person by age and sex, Australia 2001

Age Group (in years)	Male	Female
0-4	1.35	1.14
5-9	1.28	1.07
10-14	1.23	1.01
15-19	1.30	1.93
20-24	1.30	2.54
25-29	1.51	2.50
30-34	2.07	3.21
35-39	2.78	3.91
40-44	3.88	5.05
45-49	5.51	6.86
50-54	7.78	9.76
55-59	12.23	15.96
60-64	17.89	23.78
65-69	26.69	32.70
70-74	32.60	36.76
75-79	34.15	40.41
80-84	25.80	44.41
85 and over	32.04	48.35

Source: Calculation using Medicare Australia(2009b) data

The average benefit received per script was calculated at the national level ($27.03 per script (based on calculations using Medicare Australia data(2009a)), due to this being the only readily available data. To calculate the total benefits received for scripts per person, the number of scripts is simply multiplied by the average benefit per script.

In future development of the health module, the cost per script will be refined to be estimated by the two key PBS categories - concessional patients and general patients. In Australia, the benefit provided, and co-payment required, is based on the possession of a variety of government concession cards such as pensioner, health care cards and seniors cards. In 2001, the co-payment required by a concessional patient was $3.50 compared to $21.90 for a general patient, with the government meeting the difference in the cost between the co-payment and the actual cost of the script.

The initial development of the *hospital* sub-module has been more complex, as hospital visits are a rarer event in the general population. The ABS National Health Survey (NHS) 2001 was used for the modelling of the likelihood of having a hospital visit in a 12 month period and then the number of hospital visits the individual was likely to have (given they had at least one hospital visit). The likelihood of having a hospital admission was modelled using logistic regression, with the explanatory variables being age, sex and income. These three variables are significant determinants of having a hospital admission. In this initial modelling, the requirement was to implement a simple equation, which can be increased in complexity at a later stage. It is anticipated that when later stages of the health module are built, health status and private health insurance could be used as additional determinants of having a hospital admission. The current equation to determine the probability of having a hospital admission is presented in Box 1.

Box 1

$$\Pr(hosp\_visit) = -2.8 + 0.012 * age + 0.12 * sex + 0.34 * inc\_q1 + 0.36 * inc\_q2 + 0.13 * inc\_q3 + -0.05 * inc\_q4$$

where age is age in years
sex is 1=male 2=female
inc_q1 is first quintile of equivalised income unit gross income
inc_q2 is second quintile of equivalised income unit gross income
inc_q3 is third quintile of equivalised income unit gross income
inc_q4 is fourth quintile of equivalised income unit gross income

The event of having a hospital visit was allocated using monte carlo simulation. After the initial imputation of hospital services onto APPSIM was completed, it was immediately obvious that adjustments were needed. At this stage, the probabilities generated by the above equation were doubled. A more detailed discussion of the adjustment is presented in the validation section.

Next the number of hospital admissions was allocated. A probability table from the ABS NHS 2001 data was calculated to allocate between one and five or more hospital admissions in a 12 month period by age and income group. Gender was not included as it was found not to be a significant factor in the number of hospital admissions (given the individual had at least one hospital admission).

For each hospital admission the average length of stay was allocated based on AIHW hospital separation data provided by age-sex groups (see Table 5). To do this, it has been assumed that a hospital separation is equivalent to a hospital admission.

Table 5 Average length of stay per hospital admission by age and sex, Australia 2001

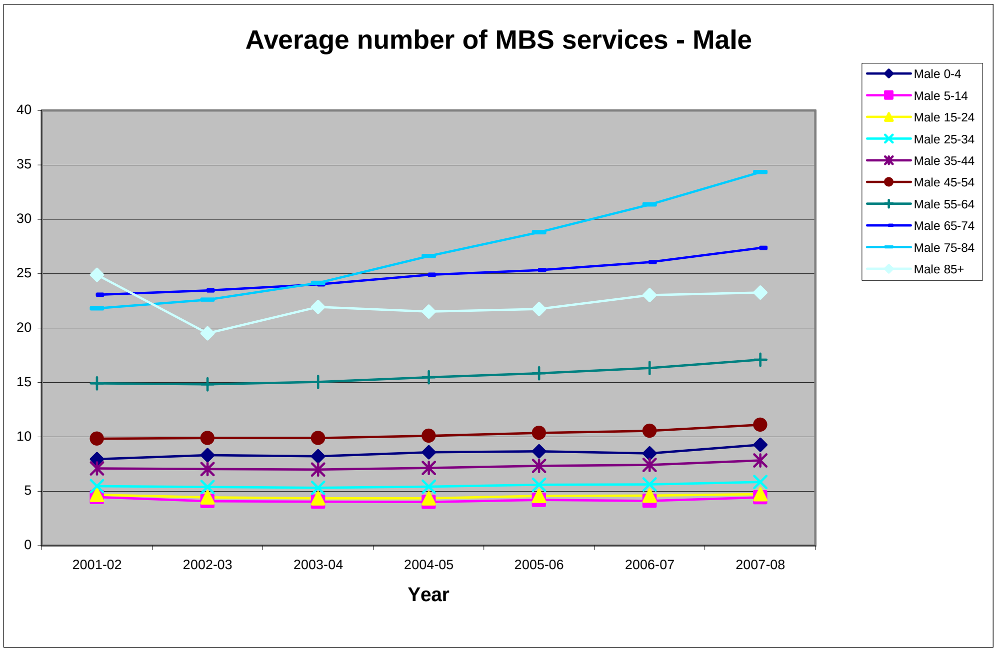
Age Group (in years)	Male	Female
<1	4.9	5.5
1-4	1.7	1.8
5-9	1.7	1.7
10-14	2.0	2.4
15-19	3.0	2.7
20-24	3.5	2.5
25-29	3.7	2.9
30-34	3.3	3.0
35-39	2.9	2.8
40-44	2.9	2.6
45-49	2.6	2.6
50-54	2.7	2.6
55-59	2.9	2.9
60-64	3.2	3.0
65-69	3.5	3.4
70-74	3.9	4.1
75-79	4.6	5.4
80-84	5.7	7.0
85 and over	8.1	9.7

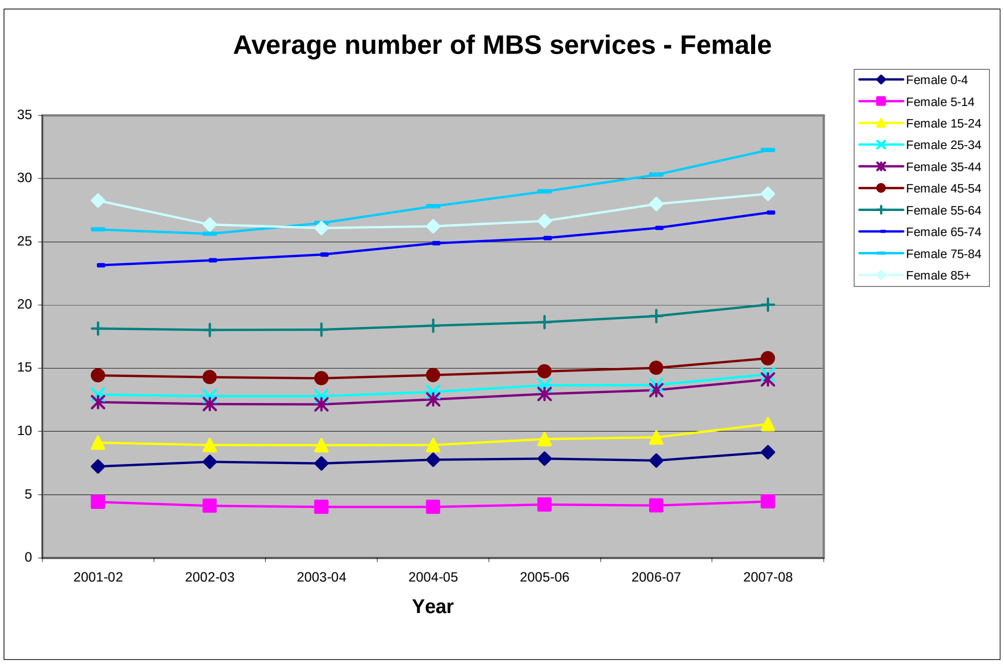
Source: Calculation using AIHW (2009b) hospital data cubes,

Finally, the average cost per bed-day for 2001 of $115.25 (based on calculations using AIHW expenditure data (2009a) and AIHW hospital separations data (2009b)) was applied. The cost data is at an aggregate level, as finer level information is not readily available. The total cost of hospital stay per individual is the number of admissions multiplied by the average length of stay multiplied by the average cost per day.

To advance the modelling beyond the steady state assumptions that have been initially applied, analysis of historical trends of the three sectors has been started. The growth pattern for MBS services will be estimated between 2001 and 2008 for age-sex groups. Analysis to date has considered both the change over time of the average annual number of MBS services per person (illustration of trends is shown in Figure 3) and the average cost per MBS service (illustration of trends is shown in Figure 4). This growth factor will be applied to *MBS services* to account for the changes in medical practice and demand for health services over time and the increases in medical service usage. In contrast, the growth factor on *average cost* per MBS service accounts for the increasing costs of advancing technology. Under this scenario it will initially be assumed that the growth rates experienced in this 2001-08 time frame are going to be maintained over the projection time frame (although such assumptions will be able to be varied).

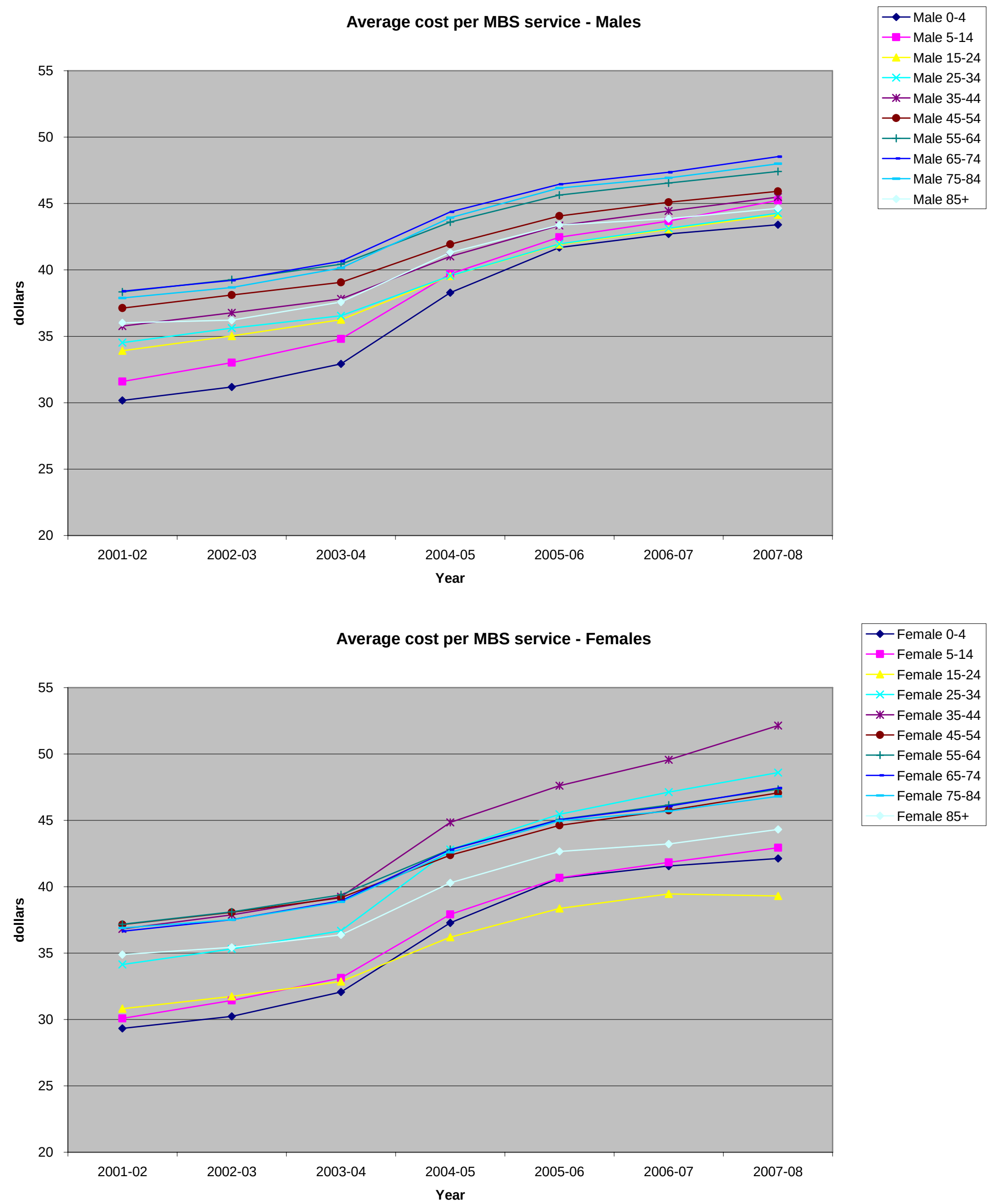
Figure 3 Average annual number of MBS services per person by sex and age, Australia 2001-2008





Source: (Health Insurance Commission 2003, 2004, 2005; Medicare Australia 2006, 2007, 2008)

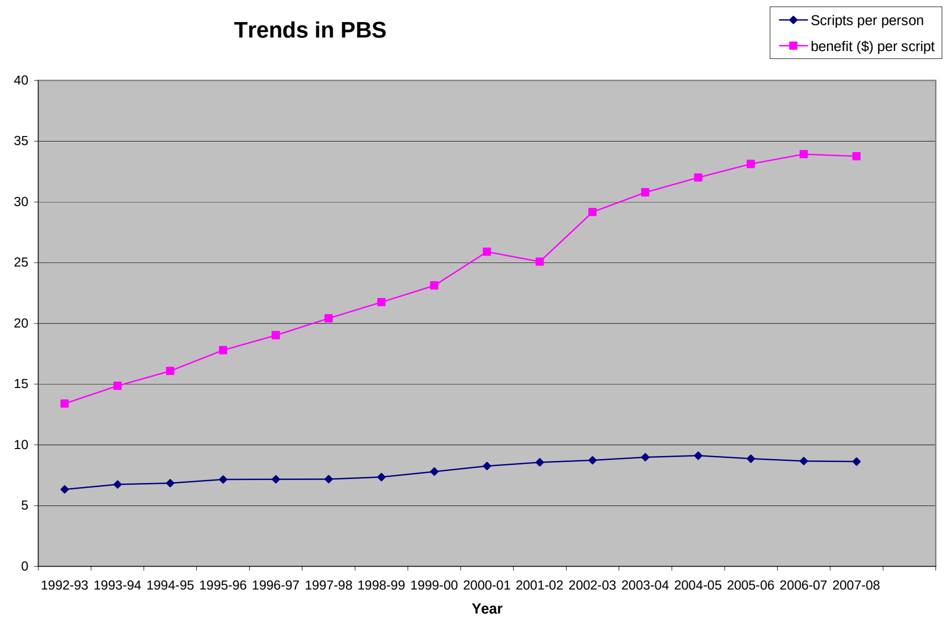
Figure 4 Average cost per MBS service ($) by sex and age, Australia 2001-2008



Source: : (Health Insurance Commission 2003, 2004, 2005; Medicare Australia 2006, 2007, 2008)

Moving to the possible growth rates to be applied to pharmaceuticals, analysis is being done on the trends in numbers of scripts per person between 1992 and 2008 across the Australian population (illustration of trends is shown in Figure 5). Sub-population analysis has not been possible due to data unavailability. This growth factor will provide a basis for the forward projections of the number of scripts per person in the model.

Figure 5 Cost per script ($) and annual number of scripts per person, Australia 1992-2008

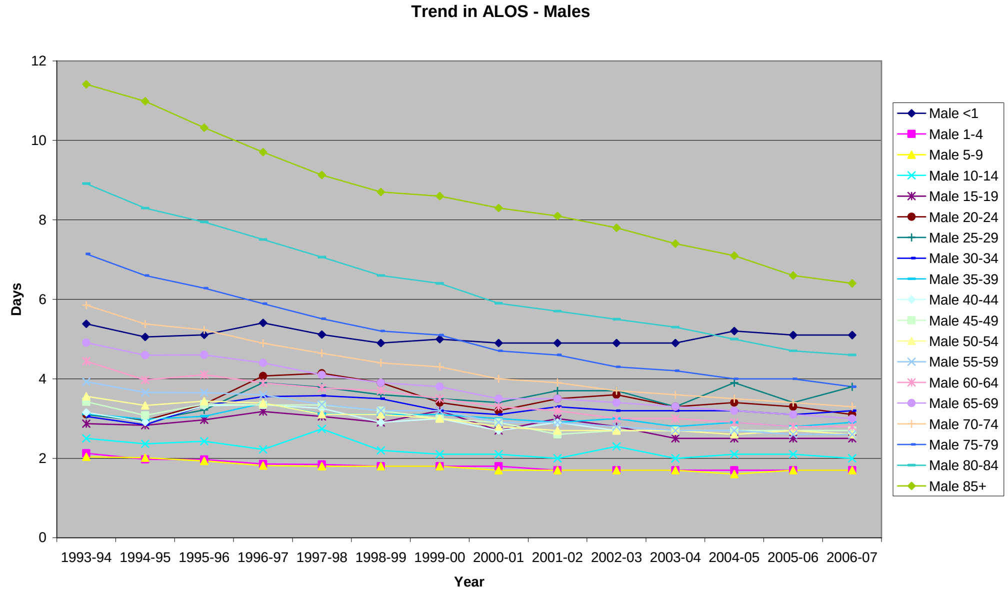


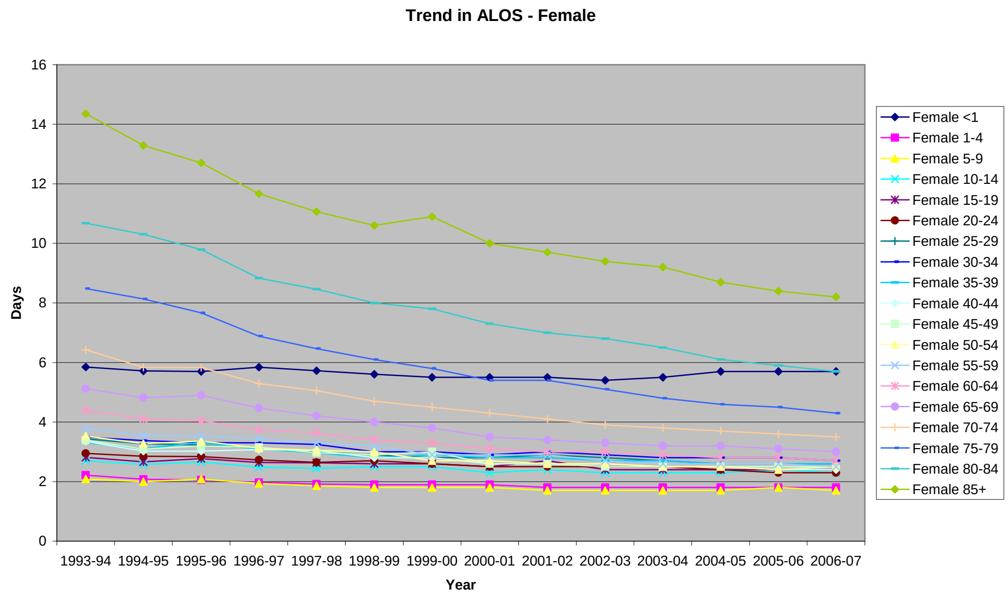
Source: Based on Medicare Australia data (2009b)

Analysis was also done on the trends in average cost per script between 1992 and 2008 to provide a growth factor to account for health cost inflation related to pharmaceuticals.

Finally, moving to the hospital sector, trend analysis has been done to consider the change in average number of hospital admissions, average length of stay (ALOS) and average cost per bed day in Australia between 1993 and 2007. This analysis was done separately for age-sex groups. As illustrated in Figure 6, the change over time of ALOS for the different sub-populations has varied widely. This is also true for average number of hospital separations. Analysis of cost per hospital bed day was analysed at the national level.

Figure 6 Average length of stay in hospital per separation, by sex and age, Australia 1993-2007





Source: AIHW Hospital data cubes **(2009b)**

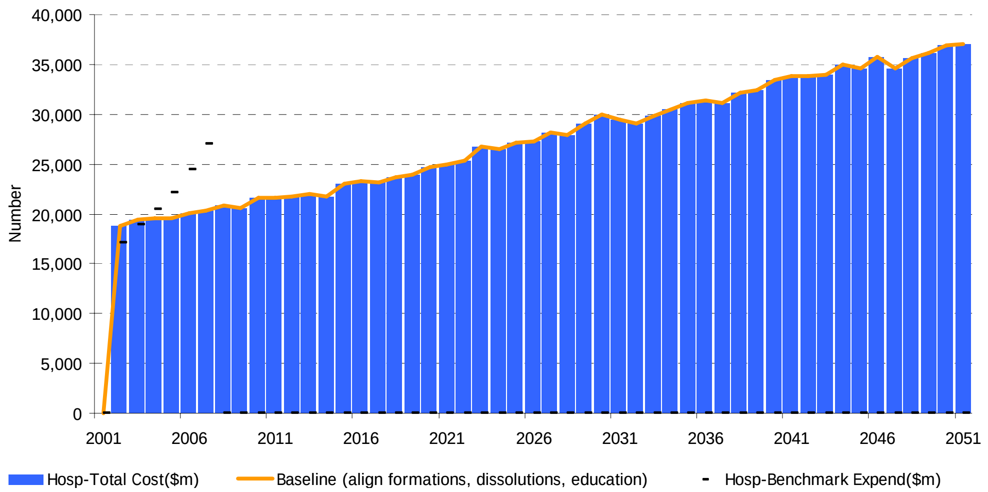
PRELIMINARY RESULTS FROM STAGE 1 STEADY STATE MODELLING

To date, the initial stages of the health modelling with steady state assumptions has been implemented - that is, both health service utilisation and health expenditure by the Australian government have been modelled at a simple level and applied within APPSIM. As mentioned previously, the private costs of health services are yet to be included in the model. The model produces aggregate estimates of total health service usage and Commonwealth government expenditure within each of the three sectors, as well as for all health. Some illustrative examples of the initial output from the APPSIM health module are shown in Figures 7-12. Considering Figure 7, the blue bars show the estimated total cost of hospital admissions for each year from 2001 to 2051 under the assumptions of the current simulation. The yellow line is to allow comparison between scenarios. Currently, only the one set of assumptions have been simulated, so the yellow line traces the same estimates as the blue bars. Finally, the black dots show the benchmark data of actual total cost of hospital separations between 2001 and 2007 obtained from AIHW. This pattern of the yellow line being the estimates of simulation 1, the blue bars being estimates of simulation 2 and the black dots being benchmark data (that is, actual data about the indicator of interest) is followed in all figures presenting output from the APPSIM health module.

For each of the sectors, as expected, it was projected that there would be increases in both the services used and the costs to government of providing those services. With the steady state assumptions in place, this is purely a reflection of the structural population ageing that is expected over the next 50 years. (That is, it is important to emphasise again that this version of the modelling effectively assumes that the 2001 usage rates and costs to government by age and sex of health services remains constant and thus that there is no 'non-demographic' growth factor applied to service use or service costs.) Such a steady-state implementation provides an important initial benchmark for testing the output of the APPSIM health module, against which future refinements can be evaluated. At this early stage, the indicative trends shown in the output are the main item of interest, rather than the absolute values of cost.

This initial output from the prototype health module demonstrates that, if the circumstances of 2001 were to continue and rates of health services use and the cost associated with these services were maintained, then the effect of an ageing population is to increase health care costs, which is in line with all other Australian projections of health expenditure. However, the rate of increases actually seen in health service expenditure between 2001 and 2008 for all sectors was far greater that that projected if population structural ageing was the only factor increasing expenditure. This reiterates that population ageing is only one component of the escalating health expenditure that has been seen in recent times. Similar results were found by Walker et al in their investigation on the cost of PBS and the effects of ageing, changing health status and increasing costs of medicines. They found that ageing produced a 50 per cent increase in PBS costs whilst increased drug prices caused a dramatic five fold increase in expenditure (Walker et al. 2000).

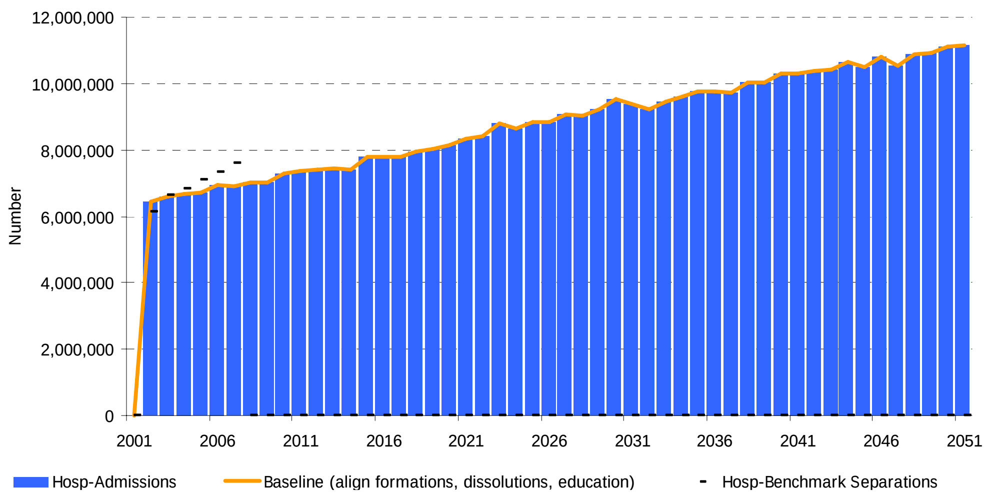
Figure 7 Projected total government cost of hospital admissions in Australia, 2001-2051



Note: The graph shows initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: APPSIM

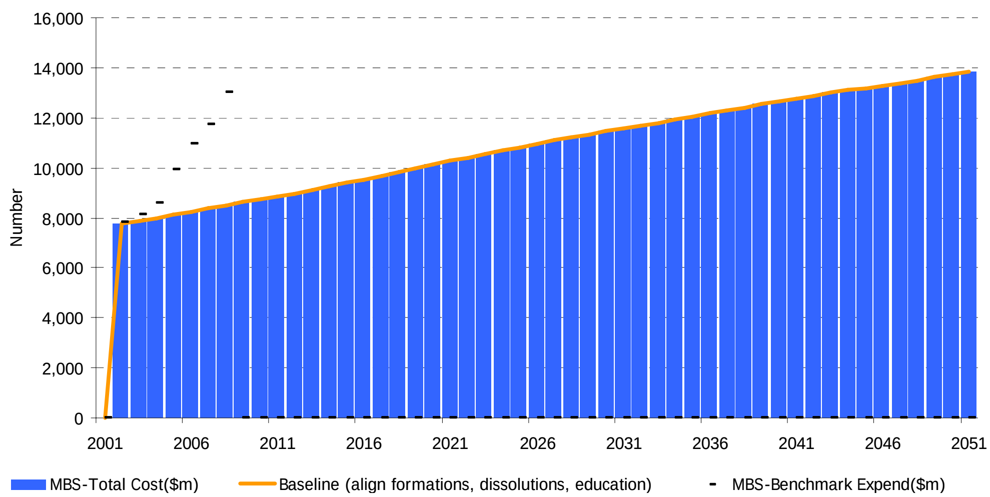
Figure 8 Projected hospital admissions in Australia, 2001-2051



Note: The graph shows initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: APPSIM

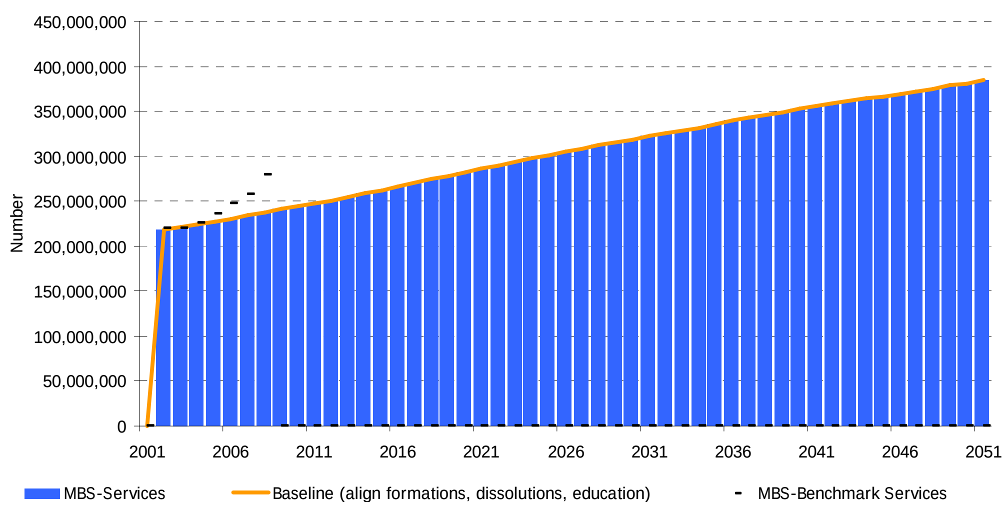
Figure 9 Projected total Commonwealth Government expenditure on MBS, 2001-2051



Note: The graph shows initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: APPSIM

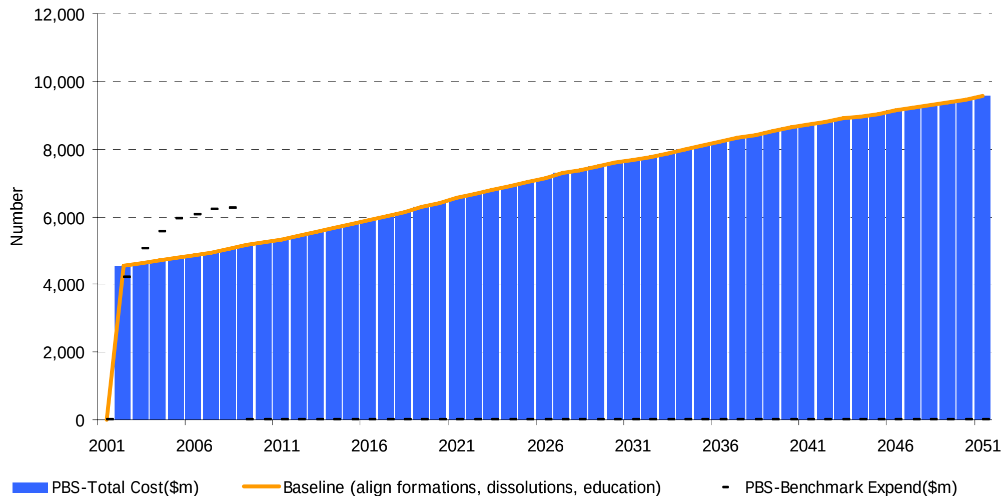
Figure 10 Projected MBS services provided in Australia, 2001-2051



Note: The graph shows initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: APPSIM

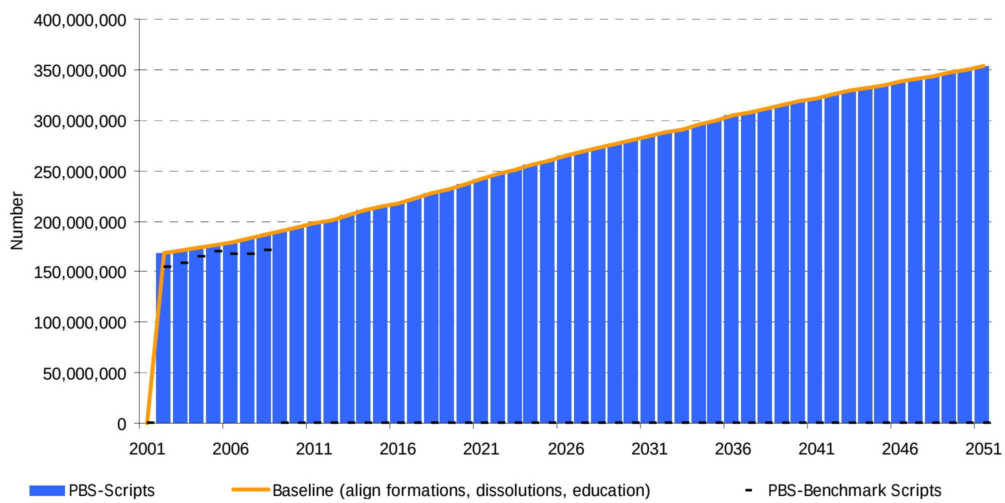
Figure 11 Projected total Commonwealth Government expenditure on PBS, 2001-2051



Note: The graph shows initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: APPSIM

Figure 12 Projected PBS scripts provided in Australia, 2001-2051



Note: The graph shows initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: APPSIM

VALIDATION

Having produced some initial output from the APPSIM health module, validation is an important next stage. Validation plays an important part in the development of any microsimulation model as this enables the measurement of the strength and accuracy of the model (Cassells et al. 2006). Morrison has described validation as "a systematic treatment of identifying and fixing threats to the model's results and its credibility (2008, p. 21). As part of the development of the health module, it is vital that appropriate and adequate validation is undertaken. Separate validation for each sub-module within the health module will be undertaken as an iterative process as each sub-module is completed.

It is important to compare characteristics within the model against credible exogenous totals and distributions (Morrison 2008). By running of the model from 2001 (base year), we have actual external benchmark data for the years 2001 through to 2008 with which to compare our model's outputs. Consideration of the time frame for which there is actual data allows us to see if the model is starting to deviate too far from reality in the initial years of the model. If marked deviation is seen, this calls for revision of the model to attempt to better represent the processes of the system being modelled. This method of validation has been recommended in several reviews of dynamic microsimulation (Zaidi and Rake 2001; Cassells et al. 2006; Spielauer 2007).

At a later stage, sensitivity analysis will be done. This offers an important initial step in validation and allows the establishment of "*the impact of specific parameters on model output*" (Zaidi and Rake 2001, p. 21). The importance of sensitivity analysis was reiterated by Cassels at al (2006). An example of how this will be implemented is that, within the health expenditure sub-module, the model will be run with several variations of the non-demographic growth factor to determine how much fluctuation is then created in total health expenditure.

Finally, an attempt will be made to provide an indication of the uncertainty surrounding the key estimates that are output from the APPSIM health module, such as MBS expenditure, PBS expenditure and hospital admissions expenditure. There are few examples of microsimulation models where this aspect of validation has been attempted. One exception is the Future Elderly Model (Goldman et al. 2004), where they have used resampling techniques to provide a prediction interval. The use of resampling techniques provides a way of estimating the sources of sample variability and provides a method of assessing the size of the error resulting from the monte carlo processes used in the microsimulation model (O'Donoghue 2001). It is anticipated that appropriate computer code will be developed to allow the calculation of prediction intervals around health expenditure using resampling methods similar to those used in the Future Elderly Model.

With the early development of the health module the key validation that is being undertaken at this time is the comparison of the simulation results from 2002-2008 with key external aggregate benchmark data, as these are the years for which we have actual data. Illustrative examples of the validation are presented in tables 6-8. The relatively simple imputation for MBS and PBS performed well in the years close to 2001, with the MBS imputation providing a slightly better replication of those first couple of years. As we moved further from 2001, health policy changes and excess health inflation have seen the reality diverge from the simulation. This is confirmation of the importance of including a growth factor for both the use of health services and the cost of health services.

The original imputation of hospital usage in 2001 was grossly underestimated compared to actual usage of hospitals in Australia (see table 8). This has occurred due to the poor representation of hospital service usage on the ABS NHS. Because of the scope of the survey – it does not include those in non-private dwellings – it has been found that only about half of the actual number of hospital admissions in a year are reflected on the ABS NHS (Ranmuthugala et al. 2008). Consequently, a parameter alignment process was undertaken whereby the probabilities of having a hospital visit were adjusted. This is a similar process to that used in DYNACAN(Dussart and Morrison 2000) and has also been described by in detail by Baekgaard (2002). This has provided better projections of aggregate hospital admissions in the simulation. Further investigation needs to be undertaken with regard to the effects of using such an alignment process.

Table 6 MBS sub-module validation

Indicator		2002	2003	2004	2005	2006	2007	2008
Total MBS expenditure ($million)	Medicare Aust.	7 841	8 116	8 600	9 923	10 976	11 736	13 007
	APPSIM	7 763	7 861	7 960	8 075	8 224	8 373	8 504
MBS services	Medicare Aust.	219 785 851	220 357 775	226 382 151	236 315 912	247 366 876	257 892 389	278 718 317
	APPSIM	217 695 616	220 357 775	223 054 498	226,168,432	230,249,198	234,385,205	238,018,269

Note: The table provides initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: Medicare Australia and APPSIM

Table 7 PBS sub-module validation

Indicator		2002	2003	2004	2005	2006	2007	2008
Total PBS expenditure ($million)	Medicare Aust.	4 225	5 063	5 564	5 933	6 052	6 194	6 237
	APPSIM	4 528	4 604	4 668	4 738	4 845	4 967	5 065
PBS scripts	Medicare Aust.	154 222 297	158 232 646	165 064 748	169 576 300	167 558 928	167 719 110	170 466 539
	APPSIM	167 503 208	170 328 742	172 686 243	175 273 036	179 253 835	183 772 308	187 379 525

Note: The table provides initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

Source: Medicare Australia and APPSIM

Table 8 Hospital sub-module validation

Indicator	Source	2002	2003	2004	2005	2006	2007	2008
Total hospital separations	AIHW		6 645 000	6 841000	7 091000	7 312 000	7 603 000	na
	APPSIM v1	3 135 627	3 370 915	3 329 759	3 412 848	3 357 714	3 443 132	3 419 060
	APPSIM v2	6 564 781	6 656 412	6 695 238	6 755 808	6 828 025	6 852 097	6 991 096
Total hospital expenditure ($million)	AIHW	17 163	18 961	20 437	22 091	24 441	26 964	na
	APPSIM v1	1 191	1 291	1 264	1 299	1 286	1 324	1 321
	APPSIM v2	18 778	19 420	19 562	19 496	20 064	20 332	20 872

Note: The table provides initial output from the prototype health module where expenditure varies only due to demographic change, not to changing service usage within age/sex groups or growth in service cost due to such factors as technological change.

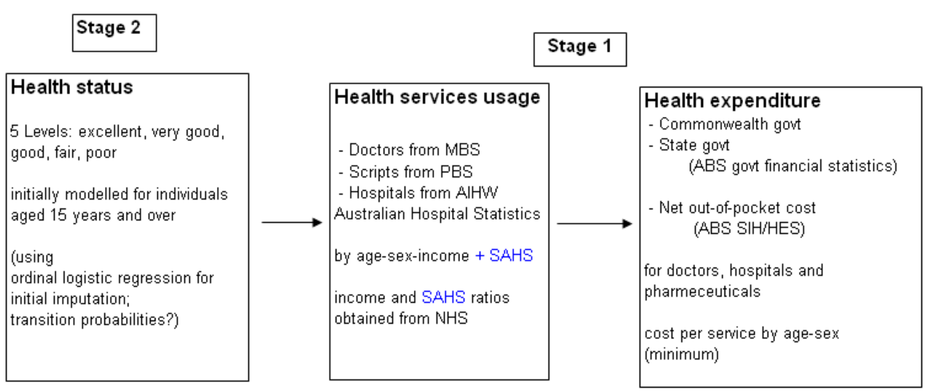
Source: AIHW and APPSIM

Future Modelling

After the completion of the initial two sub-modules of 'health services usage' and 'government health expenditure', the health status sub-module will be developed and then integrated with the health service usage sub-module, as per Figure 13. An appropriate health status indicator needs to be identified. Initially, self-assessed health status (SAHS) is to be trialled, due to its easy availability in Australian longitudinal data. In the literature, self-assessed health status has been shown to be a good indicator of morbidity (Mant et al. 1998; Balkrishnan and Anderson 2001; Woo et al. 2007) and mortality (Mossey and Shapiro 1982; McCallum et al. 1994; Idler and Benyamini 1997). In the first instance, self-assessed health status needs to be imputed onto the basefile, and then transitions need to occur across time. The initial imputation of the SAHS will use a table of probabilities from the ABS NHS 2001, based on age-sex-income groupings. In future development, the imputation may change to use an ordinal logistic regression model, using more determinants of SAHS to calculate the probabilities of an individual having each level of SAHS. The method of calculation of the transition probabilities between health states is yet to be decided. A monte carlo simulation will be used to allocate the individual's health status and, subsequently, their transitions through health states. For example, suppose that statistical models suggest that one per cent of a particular population sub-group should be selected to go from 'fair health' to 'poor health'. This is then achieved by comparing this probability against a randomly generated uniformly distributed number, where those in the sub-group whose random number is equal to or less than 0.01 are chosen to actually make the transition.

Once projected health status is established, the health service usage allocation will be expanded to differentiate usage between various health status levels, as well as age-sex-income groups. Health expenditure will be allocated as previously.

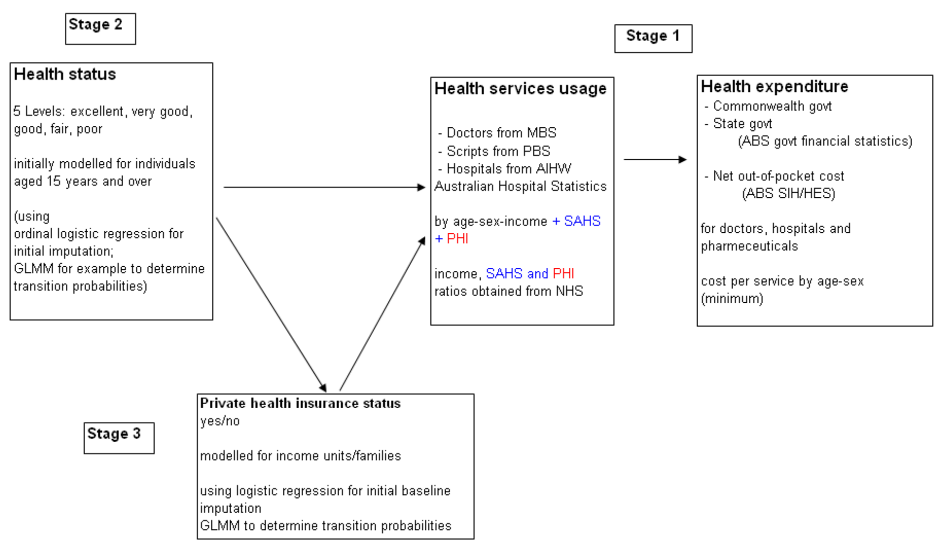
Figure 13 Stage two of health module development



The final module in the current development of APPSIM's health module is the allocation of an individual's coverage by private health insurance status, as illustrated in Figure 14. The uptake of private health insurance (PHI) has been found to be related to health status (Doiron et al. 2008). This has been confirmed within the data sources being used in this modelling. This is why private health insurance is to be developed after the health status sub-module, so that SAHS can be used as a determinant in the calculation of probabilities of having PHI. It is proposed that the imputation of private health coverage will have several stages. First the likelihood of an individual having private health insurance coverage will be calculated using logistic regression. Secondly, the likelihood of whether this coverage is just for the individual or the family (given that the individual has private health insurance) will be calculated. It is anticipated that data from the ABS NHS 2001 will be used for these calculations. Transition probabilities will be calculated using two logistic regression models and will be based on HILDA data that indicates whether the individual has paid for private health insurance in that year.

With the completion of the PHI sub-module, the health service usage sub-module will be refined to account for PHI status of the individual. It has been found that PHI has a significant effect on the usage of health services, particularly hospital services in Australia (Brameld et al. 2006). This refinement will allow us to better understand the effects of PHI uptake on both health service usage and health expenditure over time.

Figure 14 Stage three of health module development



SUMMARY

Health is a large and complex area to model in microsimulation. This is made more difficult when the basefile of choice for the microsimulation model within which the health module is sited contains no health data. To offset some of the risk in such a modelling exercise, the process has been staged, commencing with simple modelling of health service usage and health care costs to attempt to "quickly" produce output from the model. At the completion of this process, a health status sub-module will be implemented, followed by a private health insurance sub-module. With the introduction of these additional sub-modules the health service usage and costing sub-modules can be refined to account for these additional factors. By allowing such flexibility in the development of the health module it means that, in the future, additional areas of health may be included into the model without having to start from scratch. The flexibility of the model design also facilitates the easy running of scenarios and sensitivity analysis.

To date simplistic modelling of health services usage and government costs have been implemented to allow early development of the health module infrastructure. This has also allowed planning of validation and possible sensitivity analysis as more complexity is included in the module. At the completion of the initial health service and cost modules, health status modelling will be undertaken, followed by modelling of private health insurance. With the inclusion of these sub-modules, new refinements will be made to the original sub-modules. Through out this process it anticipated extensive validation will also be carried out, to ensure reliable output for reporting.

REFERENCES

ABS 2003, *National Health Survey: Users' Guide, 2001*, Cat no.4363.0.55.001, Canberra, ABS.

ABS 2008, Australian Historical Population Statistics, 2008, Cat No. 3105.0.65.001,ABS, http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3105.0.65.0012008?OpenDocument, Canberra Accessed 29 April 2009.

AIHW 2008a, Australia's Health, *Cat. no. AUS 99*, Canberra, Australian Institute of Health and Welfare.

AIHW 2008b, *Health Expenditure Australia 2006-07*, Health and Welfare Expenditure Series no. 35. Cat. no. HWE 42, Canberra, AIHW.

AIHW 2009a, Interactive expenditure data, AIHW, http://www.aihw.gov.au/expenditure/datacubes/index.cfm, Accessed 7th May 2009.

AIHW 2009b, Interactive national hospital data (data cubes), AIHW, http://www.aihw.gov.au/hospitals/datacubes/index.cfm, Accessed 7th May 2009.

Baekgaard, H. 2002, *Micro-Macro Linkage and the Alignment of Transition Processes: Some Issues, Techniques and Examples*, Technical Paper no. 25, Canberra, NATSEM, University of Canberra.

Balkrishnan, R. and Anderson, R.T. 2001, Predictive power of a risk-assessment questionnaire across different disease states: results in an elderly managed care enrolled population, *The American Journal Of Managed Care*, vol.7, no. 2, pp. 145.

Begg, S., Vos, T., Goss, J. and Mann, N. 2008, An alternative approach to projecting health expenditure in Australia. What we can expect of our health care system? *Australian Health Review*, vol.32, no. 1, pp. 148-155.

Blumberg, L.J., Shen, Y.-C., Nichols, L.M., Buettgens, M., Dubay, L.C. and McMorrow, S. 2003, *The Health Insurance Reform Simulation Model (HIRSM): Methodological Detail and Prototypical Simulation Results*, Washington, Urban Institue.

Brameld, K., Holman, D.A. and Moorin, R. 2006, Possession of health insurance in Australia - how does it affect hospital use and outcomes? *J Health Serv Res Policy*, vol.11, no. 2, pp. 94-100.

Cassells, R., Harding, A. and Kelly, S. 2006, Problems and Prospects for Dynamic Microsimulation: A Review and Lessons for APPSIM, *Discussion Paper no. 63*, Canberra, NATSEM, University of Canberra.

Commonwealth Dept of Health and Aged Care 2000, *The Australian Health Care System: An Outline*, Canberra, Financing and Analysis Branch, Commonwealth Department of Health and Aged Care.

Doiron, D., Jones, G. and Savage, E. 2008, Healthy, wealthy and insured? The role of self-assessed health in the demand for private health insurance, *Health Economics*, vol.17, no. 3, pp. 317-334.

Dussart, B. and Morrison, R. 2000, *Overview of DYNACAN - a fully-fledged Canadian actuarial stochastic model designed for the fiscal and policy analysis of social security schemes*, Ottawa, International Actuarial Association.

Fries, J.F. 1980, Aging, Natural Death, and the Compression of Morbidity, *New England Journal of Medicine*, vol.303, pp. 130-135.

Garrett, A.B., Clemans-Cope, L., Masi, P. and Bovbjerg, R.R. 2008, *State Coverage Initiatives. The Urban Institute's Microsimulation Model for Reinsurance: Model Construction and State-Specific Application*, Washington, Urban Institute.

Goldman, D.P., et al. 2004, *Health Status and Medical Treatment of the Future Elderly*, TR 169, Santa Monica, RAND Health for the Centers for Medicare and Medicaid Services.

Gruber, J. 2000, *Tax Subsidies for Health Insurance: Evaluating the Costs and Benefits*, Technical Paper, Kaiser Family Foundation.

Gupta, A. and Harding, A., (eds), 2007, *Modelling Our Future: Population Ageing, Health and Aged Care*, International Symposia in Economic Theory and Econometrics, Amsterdam, North Holland, Elsevier B. V.

Harding, A. 2007, 'APPSIM: The Australian Dynamic Population and Policy Microsimulation Model', paper presented at the Presentation to the Technical Workshops of the 1st General Conference of the International Microsimulation Association, Vienna, Austria, 20-22 August.

Health Insurance Commission 2003, *Annual Report 2002–03*, Canberra, Health Insurance Commission.

Health Insurance Commission 2004, *HIC 03-04 Annual Report*, Canberra, Health Insurance Commission.

Health Insurance Commission 2005, *HIC 04-05 Annual Report*, Canberra, Health Insurance Commission.

Houle, W. and Berthelot, E. 1997, *Use of POHEM to estimate direct medical costs of current practice and new treatments associated with lung cancer in Canada*, Research Paper Series, Analytical studies branch No 99, Ottawa.

Idler, E.L. and Benyamini, Y. 1997, Self-Rated Health and Mortality: A Review of Twenty-Seven Community Studies, *Journal of Health and Social Behavior*, vol.38, no. 1, pp. 21-37.

Kelly, S. 2007a, APPSIM - Objectives and Requirements, *Working paper no. 1*, Canberra, NATSEM, University of Canberra.

Kelly, S. 2007b, APPSIM - Selection of the Main Source Data File for the Base Data, *Working Paper no. 2*, Canberra, NATSEM, University of Canberra.

Kramer, M. 1980, The rising pandemic of mental disorders and associated chronic diseases and disabilities, *Acta Psychiatr Scand*, vol.62, pp. 382-397.

Lloyd, R. 2007, 'STINMOD: Use of a Static Microsimulation Model in the Policy Process in Australia' in A. Harding and A. Gupta, (eds), *Modelling our Future: Population Ageing, Social Security and Taxation*.Amsterdam, Elsevier B. V.

Luszcz, M., et al. 2007, *The Australian longitudinal study of ageing: 15 years of ageing in South Australia*, Adelaide, Centre for Aging Studies, Flinders University.

Lymer, S. 2009, *APPSIM - Modelling health*, Working Paper no 13, Canberra, NATSEM, University of Canberra.

Mant, J.W., Jenkinson, C., Murphy, M.F., Clipsham, K., Marshall, P. and Vessey, M.P. 1998, Use of the Short Form-36 to detect the influence of upper gastrointestinal disease on self-reported health status, *Quality Of Life Research: An International Journal Of Quality Of Life Aspects Of Treatment, Care And Rehabilitation*, vol.7, no. 3, pp. 221.

Manton, K.G. 1982, Changing concepts of morbidity and mortality in the elderly population, *Memorial Fund Q/Health Soc*, vol.60, pp. 183-244.

McCallum, J., Shadbolt, B. and Wang, D. 1994, Self-rated health and survival: A 7-year follow-up study of Australian elderly, *American Journal of Public Health*, vol.84, no. 7, pp. 1100-1105.

Medicare Australia 2006, *Medicare Australia 05–06 Annual Report*, Canberra, Medicare Australia.

Medicare Australia 2007, *Medicare Australia 06–07 Annual Report*, Canberra, Medicare Australia.

Medicare Australia 2008, *Medicare Australia Annual Report 2007–08*, Canberra, Medicare Australia.

Medicare Australia 2009a, Medicare Group Reports, https://www.medicareaustralia.gov.au/statistics/mbs_group.shtml, Accessed 7th May 2009.

Medicare Australia 2009b, Pharmaceutical Benefits Schedule Group Reports, https://www.medicareaustralia.gov.au/statistics/pbs_group.shtml, Accessed 7th May 2009.

Morrison, R. 2008, *Validation of Longitudinal Microsimulation Models: DYNACAN Practices and Plans*, Working Paper no. 8, Canberra, NATSEM, University of Canberra.

Mossey, J.M. and Shapiro, E. 1982, Self-rated health: a predictor of mortality among the elderly, *American Journal of Public Health*, vol.72, no. 8, pp. 800-808.

Mui, S.-L. 1999, Projecting coronary heart disease incidence and cost in Australia: Results from the incidence module of the cardiovascular disease policy model, *Australian and New Zealand Journal of Public Health*, vol.23, no. 1, pp. 11-19.

O'Donoghue, C. 2001, Dynamic Microsimulation: A Methodological Survey, *Brazilian Electronic Journal of Economics*, vol.4, no. 2.

PHIAC 2009, Statistical Trends in Membership and Benefits, PHIAC, Accessed 26 April 2009.

Polder, J.J., Barendregt, J.J. and van Oers, H. 2006, Health care costs in the last year of life-The Dutch experience, *Social Science and Medicine*, vol.63, no. 7, pp. 1720.

Productivity Commission 2005, Economic Implications of an Ageing Australia, *Productivity Commission Research Report*, Canberra, Productivity Commission.

Ranmuthugala, G., Brown, L., Lymer, S. and Thurecht, L. 2008, Hospital Admissions in the National Health Survey and Hospital separations in the National Hospital Morbidity Dataset: What is the Difference? *Australian and New Zealand Journal of Public Health*, vol.32, no. 3, pp. 276-281.

Robine, J.-M. and Michel, J.-P. 2004, Looking Forward to a General Theory on Population Aging, *J Gerontol A Biol Sci Med Sci*, vol.59, no. 6, pp. M590-597.

Seshamania, M. and Gray, A. 2004, Ageing and health-care expenditure: the red herring argument revisited, *Health Economics*, vol.13, pp. 303-314.

Simons, L., et al. 1990, The Dubbo study: an Australian prospective community study of the health of elderly., *Aust N Z J Med*, vol.20, no. 6, pp. 783-789.

Spielauer, M. 2007, Dynamic Microsimulation of Health Care Demand, Health Care Finance and the Economic Impact of Health Behaviours: Survey and Review, *International Journal of Microsimulation*, vol.1, no. 1, pp. 35-53.

Treasury 2002, Budget Paper No. 5, Intergenerational Report 2002-03, Department of Treasury.

Treasury 2007, Intergenerational Report 2007, Department of Treasury.

Walker, A., Percival, R. and Harding, A. 2000, 'The impact of demographic and other changes on expenditure on pharmaceutical benefits in 2020 in Australia' in L. Mitton, Sutherland, H. and Weeks, M., (ed.) *Microsimulation Modelling for Policy Analysis*.Cambridge, University Press.

Watson, N., (ed.). 2009, *HILDA User Manual – Release 7*, Melbourne Institute of Applied Economic and Social Research, University of Melbourne.

Werblow, A., Felder, S. and Zweifel, P. 2007, Population ageing and health care expenditure: A school of 'Red Herrings'? *Health Economics*, vol.16, no. 10, pp. 1109.

Woo, E.K., et al. 2007, Morbidity and related factors among elderly people in South Korea: results from the Ansan Geriatric (AGE) cohort study, *BMC Public Health*, vol.7, pp. 10.

Zaidi, A. and Rake, K. 2001, Dynamic Microsimulation Models: a review and some lessons for SAGE, *SAGE Discussion Paper no. 2*, London, ESRC SAGE Research Group, London School of Economics.