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by

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ABSTRACT

Considerable attention has been given in the recent past to the likely economic and social impact of Australia's ageing population. One particular aspect which continues to be the subject of increased commentary and conjecture, is the need and subsequent costs for Long Term Care (LTC). In this paper, a multiple state projection model based on a framework by Rickayzen and Walsh (2002) is constructed in order to project the number of people in Australia who are likely to require LTC.

KEYWORDS

Long Term Care; Disability; Multiple State Model

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1.0 INTRODUCTION

Australia, as with many of its OECD counterparts, will be burdened by an ageing population which is set to increase in both absolute terms and as a percentage of the total population. While it is certain that the consequence of such a demographic transition will have an apparent impact on the likely costs of aged care services, the relative magnitude of such affects remains without consensus.

This paper contributes to the aged care discourse by investigating the likely number of people in Australia who will be requiring Long Term Care (LTC) over the coming decades, and by attaching a cost to this projected demand. The paper will begin by reviewing the previous literature on this subject to date. A multiple state model will then be constructed and applied to Australian disability prevalence rate data and projected to 2051. In addition, the costs of providing LTC will be analysed and projected in conjunction with the results from the multiple state model. Finally, the conclusions to the study will be presented along with their limitations and suggestions for further research.

2.0 LITERATURE REVIEW

The vast majority of the literature on this subject emerges from the United States and Europe. Australian papers which have addressed the need for, and costs of, long term care are limited to Pollard (1995), Walsh and De Ravin (1995), McCallum (1998), Howe and Sarjeant (1999), Madge (2000) and Allen Consulting Group (2002).

In these papers alone, a wide range of methodologies have been employed. For instance, Pollard (1995) uses life table techniques to determine the need for LTC. Through comparison with Australian life tables, Pollard (1995) suggests that LTC need may be determined through rudimentary manipulation of life table functions. Walsh and De Ravin (1995), on the other hand, fitted trends in the prevalence of disability in Australia over the period 1981 to 1993 using regression techniques and have projected these trends to 2040 assuming trends in future prevalence being similar to current fitted patterns. Also, Madge (2000) undertakes a detailed analysis of LTC unit costs and trends and projects the LTC expenditure in Australia using an econometric forecast model.

McCallum (1998), Howe and Sarjeant (1999) and Allen Consulting Group (2002) have also studied the future needs for, and costs of, LTC. A detailed mathematical methodology has not, however, been detailed in their respective papers. The results of these and previous investigations will later be compared to the results of this paper.

The construction of a multiple state model was the preferred methodology for this paper. Note, however, that the use of multiple state models in the LTC context is not new. Early papers include Jones and Wilmot (1993) who develop a multiple state model using risk theory concepts, Nuttall et al (1994) who employ multiple state modeling techniques by implementing a series of three-state models to determine the need for long term care in the United Kingdom and Robinson (1996) who develops a continuous time markov chain

(CTMC) model to determine levels of LTC demand in the US according to disability status as contained in the National LTC surveys (NLTCS).

Perhaps the most recent contribution to multiple state modeling of LTC is that by Rickayzen and Walsh (2002). Starting with an initial data set from the OPCS survey of disability in Great Britain and incorporating trends in health life expectancy as exhibited within the UK General Household surveys over the last 20 years, Rickayzen and Walsh (2002) project the number of persons (aged 20 and above) in the United Kingdom who are disabled up to 2036 under several sets of assumptions. This model, which has added considerably to the complexity of that proposed by earlier multiple state models, incorporates several categories of disability ranging from relatively mild to very severe.

The multiple state model to be presented in this paper for the Australian population builds heavily on this earlier work by Rickayzen and Walsh (2002). Naturally, there are several key differences. Firstly, Rickayzen and Walsh (2002) only consider persons aged 20 and over, while this paper covers all age groups in the Australian population, thereby explicitly allowing for disabilities that may have arisen in the earlier ages. (eg birth defects). Secondly, this paper employs further functions for both disability and mortality improvements.

3.0 DATA REQUIREMENTS

3.1 Disability Data

In Australia, the most suitable data source is the results from the Survey of Disability, Ageing and Carers conducted by the ABS throughout Australia from 16 March to 29 May 1998. The results of this survey represent the most up to date information as at the time of construction of this model.

The data used for this paper are those that relate to *core activity restrictions* defined in the survey as restrictions relating to self care, mobility and communication. These core activities are summarised in Table 1.

Table 1: Core Activities

Core Activity	Includes:
Self Care	Bathing or showering; dressing; eating; using the toilet and managing incontinence.
Mobility	Moving around at home and away from home; getting into or out of a bed or chair; using public transport.
Communication	Understanding and being understood by others: strangers, family and friends.

Source: Australian Bureau of Statistics (1998). Disability, Ageing and Carers: Summary of Findings. ABS Catalogue No. 4430.0

A core activity restriction is therefore determined based on whether a person needs help, has difficulty, or uses aids or equipment with any core activity. Four levels of core activity restriction, which accordingly reflect respective levels of disability, are defined in Table 2.

Table 2: Levels of Core Activity Restriction

Level	Defined as:
Profound	The person is unable to do, or always needs help with, a core activity task.
Severe	The person sometimes needs help with a core activity task; or, has difficulty understanding or being understood by family or friends; or, can communicate more easily using sign language or other non-spoken forms of communication.
Moderate	The person needs no help but has difficulty with a core activity task
Mild	The person needs no help and has no difficulty with any of the core activity tasks, but uses aids and equipment; or, cannot easily walk 200 metres; or, cannot walk up and down stairs without a handrail; or, cannot easily bend to pick up an object from the floor; or, cannot use public transport; or, can use public transport but needs help or supervision; or, needs no help or supervision but has difficulty using public transport.

Source: Australian Bureau of Statistics (1998). Disability, Ageing and Carers: Summary of Findings. ABS Catalogue No. 4430.0

Tables 3(a) and 3(b) show the number of males and females in each age group in Australia with, and without, core activity restrictions, presented as prevalence rates per 1000 of the Australian population.

Table 3(a): Male Core Activity Restriction Prevalence Rates (per 1000).

Age	No CAR	Profound CAR	Severe CAR	Moderate CAR	Mild CAR
0 to 4	966.8	13.2	17.4	2.6	0.0
5 to 14	911.8	29.6	27.9	8.5	22.3
15 to 24	942.6	6.8	14.4	10.8	25.4
25 to 34	926.0	11.2	13.6	14.6	34.7
35 to 44	897.1	8.7	21.7	31.2	41.3
45 to 54	832.0	9.4	45.8	55.8	57.0
55 to 59	744.7	23.7	63.8	69.2	98.6
60 to 64	678.8	28.2	54.7	94.0	144.3
65 to 69	654.0	33.3	45.0	107.7	160.0
70 to 74	562.9	71.2	46.8	102.9	216.3
75 to 79	454.3	106.1	83.4	153.1	203.1
80 to 84	430.4	162.1	80.6	78.8	248.2
85 and over	168.1	431.9	127.5	104.3	168.1

Table 3(b): Female Core Activity Restriction Prevalence Rates (per 1000).

Age	No CAR	Profound CAR	Severe CAR	Moderate CAR	Mild CAR
0 to 4	984.3	9.1	3.4	3.2	0.0
5 to 14	956.6	17.1	13.5	3.5	9.3
15 to 24	953.7	8.7	8.5	5.8	23.2
25 to 34	934.2	5.8	18.9	14.4	26.8
35 to 44	890.9	9.4	30.4	30.5	38.7
45 to 54	826.2	15.9	51.0	48.9	58.0
55 to 59	737.9	16.8	62.6	82.2	100.5
60 to 64	703.5	31.5	61.2	90.0	113.9
65 to 69	671.9	36.7	54.8	89.2	147.4
70 to 74	580.9	89.7	60.8	104.3	164.4
75 to 79	466.9	156.1	92.6	101.7	182.6
80 to 84	349.9	274.5	81.6	68.8	225.3
85 and over	167.6	554.5	133.8	68.8	75.2

Source: Australian Bureau of Statistics (1998). Disability, Ageing and Carers: Summary of Findings. ABS Catalogue No. 4430.0

The prevalence data display several distinctive features.

- Prevalence rates for both males and females increase, generally, as a function of age.
- The increase in prevalence rates for both males and females appears most rapid in the profound core activity restriction category. For instance, the profound prevalence rate for males more than doubles between the 45 to 54 and 55 to 59 age group, the 65 to 69 and 70 to 74 age group and the 80 to 84 and 85 and over age group. The profound prevalence rate for females more than doubles between the 65 to 69 and 70 to 74 age group and the 80 to 84 and 85 and over age group.
- Profound and severe prevalence rates are higher, in general, for females in the higher age groups but lower in the younger age groups.

The data, however, contains several limitations which will be discussed in Section 8.1.

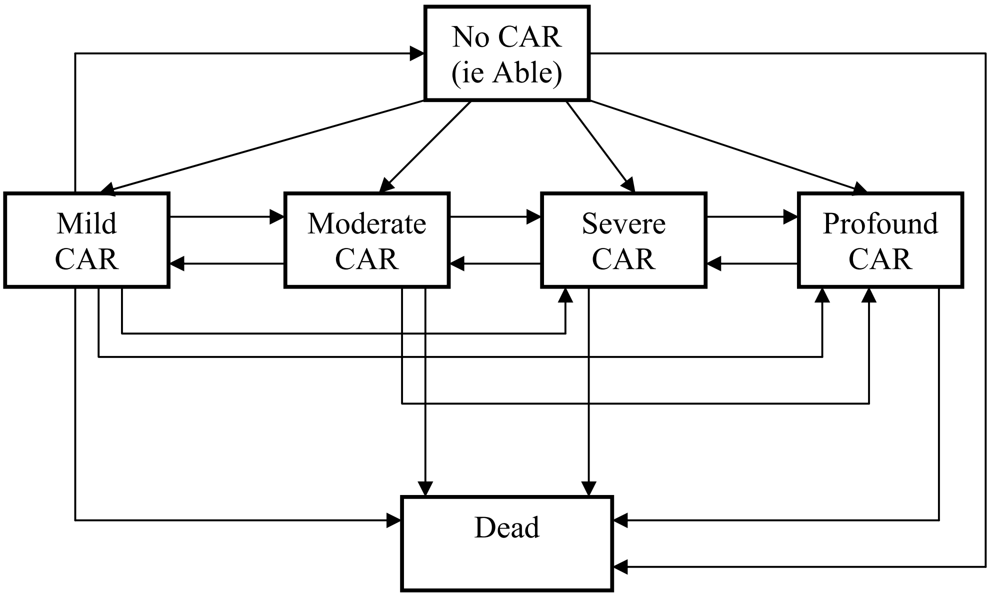
4.0 THE MULTIPLE STATE MODEL

In this section, a detailed description of the multiple state model used to determine the number of persons requiring long term care in the future is discussed. This section of the model relies on the modeling framework and formulae for estimating transition probabilities proposed by Rickayzen and Walsh (2002). However, several formulae and associated parameters for estimating transition probabilities will inevitably be different when applied to Australian data. These will be identified where appropriate.

4.1 Model Outline

The multiple state transition model (which is the same for both males and females) may be represented diagrammatically as follows:

Figure 1: Transitions in the Multiple State Model.



The model state space comprises 6 states: No CAR (ie Able), 4 levels of CAR (ie disability) and an absorbing state (ie dead). For simplicity, the live states are denoted by $\{n: n = 0 \text{ to } 4\}$ where 0 corresponds to No CAR and $n = 1$ corresponds to Mild CAR through to $n = 4$ corresponding to profound CAR. The model fitting process, transitions and the methodology for estimating the transition intensities will be discussed in turn.

4.2 Model Fit

The underlying process in this model is a discrete time Markov Chain. Ideally, a longitudinal data set would allow the calculation of transition probabilities using a maximum likelihood approach. Given that such data is unavailable, transition probabilities are found by assuming a functional form for the transition probabilities in the multiple state model and subsequently finding parameters for each function such that the initial prevalence rates are replicated over a 1 year period. That is, the parameters contained in this model have been chosen with the sole purpose of best replicating the core activity restriction prevalence rates as derived from the Survey of Disability, Ageing and Carers conducted by the ABS in 1998. As with Rickayzen and Walsh (2002), our data constraints are such that we implicitly assume a stationary population structure for the purposes of deriving transition probabilities.

An optimization procedure using Solver in Excel was used to set the sum of the squared difference of the prevalence rates in the data and the corresponding prevalence rates in the model to zero. As can be seen in Table 4(a) and 4(b), which shows the difference in prevalence rates, expressed in percentage terms, an exact match is not possible. However, a set of parameters determined by Solver which provided a minimal difference and also appropriately reflected the underlying process was used.

Given the large number of parameters to be estimated and the complex structure of the data, identifiable patterns are difficult to recognise. Moreover, any mathematical function such as those used in this paper to estimate the transition probabilities will never fully and exactly replicate the erratic reality of disability onset, deterioration and improvement. While this model is unable to completely match the data, the parameters chosen were felt to provide a sufficient fit.

Table 4(a): Difference in male prevalence rates between data and model in percentage terms

Age	No CAR	Profound CAR	Severe CAR	Moderate CAR	Mild CAR
0 to 4	0.60%	0.00%	0.03%	-0.23%	-0.39%
5 to 14	-0.12%	0.23%	0.16%	-0.24%	-0.03%
15 to 24	0.74%	-0.26%	-0.11%	-0.14%	-0.23%
25 to 34	0.25%	0.01%	-0.02%	-0.08%	-0.16%
35 to 44	0.31%	-0.10%	0.12%	0.15%	-0.48%
45 to 54	0.33%	-0.15%	0.47%	0.24%	-0.90%
55 to 59	-0.58%	0.11%	0.65%	0.12%	-0.30%
60 to 64	-0.22%	-0.16%	-0.08%	0.57%	-0.11%
65 to 69	0.39%	-0.15%	-0.29%	0.67%	-0.62%
70 to 74	-1.47%	0.72%	-0.38%	0.07%	1.07%
75 to 79	-0.84%	0.47%	0.18%	1.37%	-1.18%
80 to 84	0.43%	0.85%	-1.14%	-2.81%	2.66%
85 and over	-15.54%	5.05%	1.21%	2.31%	6.96%

Table 10(b): Difference in female prevalence rates between data and model in percentage terms

Age	No CAR	Profound CAR	Severe CAR	Moderate CAR	Mild CAR
0 to 4	0.59%	-0.03%	-0.08%	-0.08%	-0.40%
5 to 14	0.33%	0.08%	0.06%	-0.19%	-0.27%
15 to 24	0.40%	-0.13%	-0.10%	-0.11%	-0.07%
25 to 34	0.25%	-0.10%	0.16%	-0.03%	-0.27%
35 to 44	0.02%	-0.05%	0.26%	0.14%	-0.37%
45 to 54	-0.03%	-0.05%	0.49%	0.17%	-0.58%
55 to 59	-1.05%	-0.24%	0.56%	0.88%	-0.15%
60 to 64	0.42%	-0.02%	0.15%	0.45%	-1.00%
65 to 69	0.33%	-0.25%	-0.13%	0.28%	-0.24%
70 to 74	-0.69%	0.82%	-0.26%	0.68%	-0.55%
75 to 79	0.04%	0.48%	-0.16%	-0.13%	-0.23%
80 to 84	-1.79%	0.98%	-1.90%	-1.19%	3.90%
85 and over	-14.05%	4.07%	4.20%	2.84%	2.95%

Several comments should be made regarding the fit of the model. The prevalence rates for both males and females across all ages for the profound and severe CAR categories are quite close. This is the most important aspect of the data given its likely connection with the provision of long term care services.

Note, however, that the fit of the model is poor at the higher ages - notably ages 85 and above. As mentioned, it is inevitably difficult to obtain an optimal fit to the data. This is particularly the case here given the highly complex structure of the model and data, and with the number of parameters to be estimated. It is also likely that the formulae for transition probabilities themselves are unable to fully capture the dynamics of the disability process of a population at all ages. Further complications also arise with the issue of encountering local minima in the fitting process.

Overall, however, the difference in prevalence rates between the data and the model appears reasonably small in percentage terms (particularly in relation to the profound and severe CAR categories) to conclude that a sufficient fit to the data has been obtained.

4.3 Mortality

Both Males and Females in each state (except the absorbing state) are assumed to be subject to overall mortality in accordance with the Australian Life Tables 1995-1997. Additional mortality, however, was accorded to persons in either the severe or profound core activity restriction categories. There is limited information in Australia regarding the dependency of mortality and disability. Early studies on the interaction between mortality and morbidity were done, for instance, by Pollard (1980). More recently, however, a report by the Society of Actuaries Long-Term Care Valuation Insurance Methods Task Force (1995), suggests a maximum extra annual mortality of 0.15. Note that Rickayzen and Walsh (2002) use 0.2. This choice, however was a result of specific interviews conducted by the authors. The formula used in this study to express the extra mortality for someone aged x in CAR category n is therefore given as:

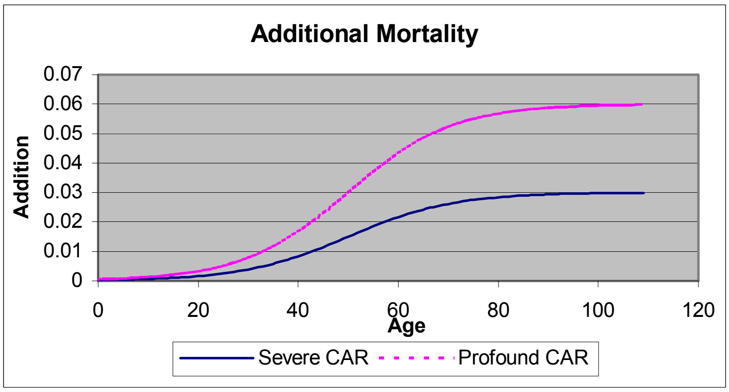
$$Additional\_Mortality(x,n) = \frac{0.15}{1+1.1^{50-x}} \cdot \frac{Max(n-2,0)}{5} \quad (1)$$

As per Rickayzen and Walsh (2002), the function aims to display the following features:

- Weak age dependence in disability related addition to healthy mortality.
- Extra mortality is low at younger ages.
- No extra mortality for persons in mild or moderate restriction categories.
- Age 50 is chosen as the pivotal age and 1.1 is chosen as the steepness factor.

Figure 2 shows the additional mortality accorded to both males and females in both the severe or profound core activity restriction categories.

Figure 2: Additional Mortality for both Males and Females



4.4 Transition to Core Activity Restriction States

The formulae used for estimating the probability of becoming disabled is the same for both males and females. It represents the probability that a person aged *x* makes a transition to any core activity restriction state in a year. The formula is logistic in nature and is expressed as:

$$New\_CAR(x) = \alpha\left\{\left(A + \frac{D-A}{1+B^{C-x}}\right) \times \left(1 - \frac{1}{3}\cdot \exp\left[-\left(\frac{x-E}{4}\right)^2\right]\right)\right\} \qquad (2)$$

where the five parameters are *A,B, C, D* and *E,* and α is a scale parameter.

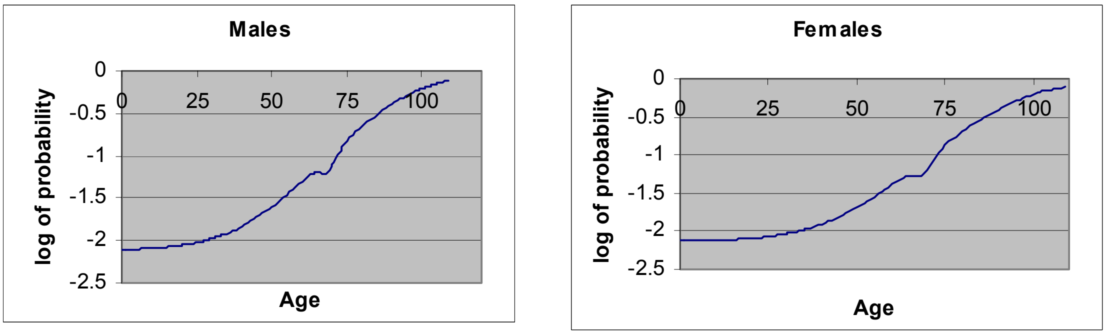
The parameter values (determined via the fitting procedure) for both males and females are presented in Table 5. Note that Rickayzen and Walsh (2002) use one less parameter for females. No distinction, however, was made here.

Table 5: Parameter Values for *New_CAR(x)*

Parameter	Males	Females
α	7.95952	7.95978
A	0.000959	0.000927
B	1.0959238	1.102981
C	93.47352	93.4994
D	0.119353	0.11935
E	68.873716	68.87697

Figure 3 shows the base 10 logarithm for the probability for both males and females in the able category acquiring a core activity restriction over a 1 year period.

Figure 3: $\text{Log}_{(10)}$ of annual probability of transition to a core activity restriction state.



Given the probability that a person aged *x* makes a transition to a core activity restriction state in a year, it is now necessary to determine which core activity restriction category that person enters. The formula for the probability that a person aged *x* will be in severity category *n* given that the person acquires a core activity restriction at age *x* is given by:

$$Severity(x,n)=\frac{W(n)\cdot f(x)^{n-1}}{Scale(x)} \tag{3}$$

$$f(x)=P+\frac{1-P}{1+Q^{R-x}} \tag{4}$$

$$Scale(x)=\sum_{n=1}^{4}W(n).f(x)^{n-1} \tag{5}$$

where *W(n)* are category widths designed to allow for some categories having more persons than others, and it is this aspect of disability that the widths of the categories are trying to allow for. *P, Q* and *R* are parameters relating to age dependence of disability and *Scale(x)* ensures that the probabilities sum to 1.

The parameter values for severity are presented in Table 6.

Table 6: Severity Parameters

Parameter	Males	Females
P	0.5129	0.3453
Q	1.4268	1.2513
R	85.0082	85.4748
W(1)	1	1
W(2)	0.6684	0.7671
W(3)	0.6732	1.6180
W(4)	1.1445	4.6020

The model also allows for deterioration once a person has a core activity restriction. Rickayzen and Walsh (2002) propose a simple function to allow for this deterioration. The probability of a person in core activity restriction category *m* deteriorating to category *n* is F^m times the probability that a person with no core activity restriction deteriorates to category *n.* That is:

$$Deteriorate(x, m, n) = Deteriorate(x, 0, n) \times F^m \tag{6}$$

where:

$$Deteriorate(x, 0, n) = New\_Car(x) \times Severity(x, n) \tag{7}$$

The deterioration factor, *F*, implemented here was 1.195 for males and 1.250 for females.

4.5 Improvement

The assumption regarding improvements is of the same form as that used in Rickayzen and Walsh (2002). That is, all persons regardless of age or current core activity restriction may only improve by one category over the year, if and only if, they survive the year and do not deteriorate during the course of the year. The improvements implemented were 5% for improvement from the profound core activity restriction category, 10% from the severe restriction category and 15% from the moderate and mild category. While the improvements, particularly from the mild and moderate category may be seen as generous, the motive for this was to compensate, in part, for the fact that the full range of improvements is not available in the model. That is, the model only allows for improvement to the able category from the mild category whereas in reality, persons from each category could possibly improve to the able state, but this is reasonably unlikely.

5.0 PROJECTIONS USING THE MULTIPLE STATE TRANSITION MODEL

Having established transition probabilities for the model, the Australian population can be projected in order to determine the number of persons in each core activity restriction category over the next 50 years. A number of assumptions are required in this section of the paper. The ABS, in their publication Population Projections Australia:1999 to 2101 (2000), project the Australian population under three sets of assumptions – high growth (Series I), medium growth (Series II) and low growth (Series III). These assumptions are the latest set issued by the ABS as at the time of this paper. Aside from mortality improvement (which will be discussed in Section 5.4), the projection assumptions in this paper are in line with the ABS Series II (2000) assumptions.

5.1 Initial Population Structure

Given that the model prevalence rates have been derived to match 1998 data, the initial population requires the number of persons in each core activity restriction category according to individual age and sex in 1998. Given that the ABS does not publish such information, prevalence rates produced by the multiple state model were applied to age group totals for each sex as reported in the Survey of Disability, Ageing and Carers (1998). Although the model prevalence rates are not fully consistent with the data prevalence rates, the discussion in Section 4.2 of this paper is assuming that any differences to the initial population structure are minimal.

5.2 Fertility

The Series II assumption in Population Projections Australia:1999 to 2101 (2000) is that the total fertility rate declines to 1.6 births per women in 2008 and remain stable at that level. The total fertility rate in 1998 of 1.758 as contained in ABS publication Births (2000) was employed as the initial total fertility rate to 2008. Moreover, the 1998 sex ratio at birth of 1.053 was implemented.

A further issue is the distribution of births according to core activity restriction. It has been assumed that births are distributed into core activity restriction categories according to the model prevalence rates.

5.3 Migration

Series II in Population Projections Australia:1999 to 2101 (2000) assumes net overseas migration of 90 000 per annum. The age distribution is assumed to be consistent throughout the projection period with the age distribution of overseas migrants in 1998.

Furthermore, the distribution according to core activity restriction categories is according to the model prevalence rates. It is also assumed that half of the migrations occur at the start of the year and the other half at the end of the year. Moreover, migrants entering Australia at the start of the year are exposed to the same decrement rates as the rest of the population.

5.4 Mortality Improvement

The mortality basis used in these projections is the Australian Life Table 1995-1997. Furthermore, an assumption regarding mortality improvement is made. The ABS assumption is an improvement in life expectancy of 0.30 years per year for females and 0.22 years per year for males for the next five years and then gradually declining to result in a life expectancy at birth of 83.3 years for males and 86.6 years for females. There is no further detail in this publication as to how these improvements are implemented as a function of age. Therefore, the following function from the Continuous Mortality Investigation Reports (CMIR) (1999) of the Institute and Faculty of Actuaries was implemented.

$$q_{x,t} = q_{x,0} \cdot RF(x,t) \tag{8}$$

where $RF(x,t)$ is the reduction factor for age x at time t.

The reduction factor, which provides for an exponential decrease in mortality toward a limiting value, is given as:

$$RF(x,t) = \alpha(x) + [1-\alpha(x)] \cdot [1-f(x)]^{\frac{t}{20}} \tag{9}$$

where:

$$\alpha(x)=\begin{cases} c & x\le 65 \\ 1+(1-c)\cdot\dfrac{(x-125)}{65} & x>65 \end{cases} \qquad (10)$$

and:

$$f(x)=\begin{cases} h & x\le 65 \\ \dfrac{(125-x).h+(x-65).k}{65} & x>65 \end{cases} \qquad (11)$$

Note that the form of $\alpha(x)$ and $f(x)$ are slightly different from the CMIR (1999). The reason for this is that slightly heavier mortality improvements at the higher ages were required to be consistent with the projected proportion of persons aged over 65 as forecasted by the ABS.

The parameters *c, h* and *k* were chosen such that a life expectancy at birth of 83.3 years for males and 86.6 years for females was achieved. Note that the complete expectation of life was defined here as:

$$\overset{0}{e}_x=\frac{1}{l_x}\cdot\left\{\left(\sum_{y\ge x} l_y\right)-\frac{l_x}{2}\right\} \qquad (12)$$

The parameter values are shown in Table 7.

Table 7: Mortality Improvement Parameters

Parameter	Males	Females
c	0.163	0.149
h	0.403	0.355
k	0.303	0.293

Note that alternative techniques may have been used for modeling future mortality such as frailty models for projecting human mortality improvements as proposed by Wang and Brown (1998). Perhaps the most popular in the literature being that of Lee and Carter (1992) who developed a method based on a combination of statistical time series and an approach to deal with the age distribution of mortality. Their model for mortality is:

$$\ln(m_{x,t})=a_x+b_x k_t+e_{x,t} \qquad (13)$$

where $m_{x,t}$ is the central death rate at age x and time t, $\{a_x\}$ are coefficients describing the average shape of the age profile and $\{b_x\}$ are coefficients describing deviation patterns from this age profile as the parameter k varies and $e_{x,t}$ is the residual.

The Lee-Carter method has not been applied here for several reasons. Booth, Maindonald and Smith (2002) have shown that the Lee-Carter assumptions are not always met when applied to Australian data due to age-time interactions. In addition, even if an adapted methodology is applied, forecasts of life expectancy are higher than official projections.

5.5 Projection Methodology

The projection methodology proposed by Rickayzen and Walsh (2002) was employed here. The projection method is essentially a component one which requires separate application to males and females. The method is as follows.

Define *Lives(x,t,n)* to be the number of lives aged *x* in year *t* in core activity restriction category *n*. Then,

$$\begin{aligned} Lives(x,t,n) = {} & \left[Lives(x-1,t-1,n) + \frac{Migrants(x-1,t-1,n)}{2} \right] \times \\ & [1 - Mortality(x-1,t-1,n)] \times \\ & [1 - Deteriorate\_From(x-1,t-1,n)] \times \\ & [1 - \mathrm{Im}prove\_From(x-1,t-1,n)] + \\ & Deteriorate\_To(x,t,n) + \mathrm{Im}prove\_To(x,t,n) + \\ & \frac{Migrants(x,t-1,n)}{2} \end{aligned} \qquad (14)$$

Mortality(x,t,n) is the probability that a person aged *x* at time *t* and with core activity restriction *n* dies in the following year. Thus:

$$Mortality(x,t,n) = q_{x,t} + Additional\_Mortality(x,t,n) \qquad (15)$$

Deteriorate_From(x,t,m) is the probability that a person aged *x* at time *t* and with core activity restriction *m* makes a transition to a more severe core activity restriction category. Thus:

$$Deteriorate\_From(x,t,0) = New\_CAR(x,t) \qquad (16)$$

and

$$Deteriorate\_From(x,t,m) = \sum_{n=m+1}^{4} Deteriorate(x,t,m,n) \qquad (17)$$

Improve_From(x,t,n) is the probability that a person who does not suffer decrement in the year, improves by one category. Thus:

$$Improve\_From(x,t,n) = \begin{cases} 0.05: & n = 4 \\ 0.1: & n = 3 \\ 0.15: & n = 1,2 \end{cases} \qquad (18)$$

Deteriorate_To(x,t,n) is the number of persons aged *x* at time *t* who make a transition to core activity restriction category *n* from a less severe core activity restriction category. Thus:

$$Deteriorate\_To(x,t,n) = \sum_{m=0}^{n-1} \{ \ Exposed\_To\_Detriment(x-1,t-1,m) \times \\ Deteriorate(x-1,t-1,m,n) \ \} \quad (19)$$

where:

$$Exposed\_To\_Detriment = \left[Lives(x,t,n) + \frac{Migrants(x,t,n)}{2} \right] \times \\ \left[1 - Mortality(x,t,n) \right] \quad (20)$$

Improve_To(x,t,n) is the number of persons aged *x* at time *t* who make a transition to core activity restriction category *n* from core activity restriction category *n+1.* Thus:

$$Improve\_To(x,t,n) = Exposed\_To\_Improvement(x\text{-}1,t\text{-}1,n\text{+}1) \text{ x } \begin{cases} 0.05: & n=4 \\ 0.1: & n=3 \\ 0.15: & n=1,2 \end{cases} \quad (21)$$

where:

$$Exposed\_To\_Improvement(x,t,n) = \left[Lives(x,t,n) + \frac{Migrants(x,t,n)}{2} \right] \times \\ \left[1 - Mortality(x,t,n) \right] \times \\ \left[1 - Deteriorate\_From(x,t,n) \right] \quad (22)$$

6.0 INCORPORATING CORE ACTIVITY RESTRICTION IMPROVEMENTS

It is reasonable to assume that changes to the likelihood of becoming disabled will occur over the next 50 years. This may be attributable to factors ranging from general improved health through to advances in medical technology. It is therefore necessary to have a mechanism within the model that allows for improvements to core activity restriction over time. Before discussing these, however, it is necessary to outline the likely core activity restriction improvements in the future.

6.1 Core Activity Restriction Improvements in the Future.

Unlike mortality, estimates for improvements in disability are given far less attention. In Australia, there is currently no official estimate of the future prevalence of disability as there is for, say, future life expectancy. Comment is predominantly restricted to changes in the prevalence of disability between the four consecutive ABS disability surveys which occurred in 1981, 1988, 1993 and 1998. Wen et al. (1995) performed a decomposition analysis which demonstrated that the overall age-standardised prevalence rate of severe or profound restriction was relatively stable during the 1980s and early 1990s at around 4%. Similar findings were also made by Walsh and De Ravin (1995) between 1981 and 1993. Madden and Wen (2001) reported that between 1993 and 1998, the estimated rate of severe or profound restriction increased from 4.1% to 6.1%. Madden and Wen (2001) are of the view that such an increase in prevalence does not reflect a substantial increase in underlying disability but rather a change in disability survey design. Davis et al. (2001) suggest that over half of the increase in prevalence between 1993 and 1998 is due to changes in survey methods. In particular, changes to screening questions and the inclusion of the SF-12 health status instrument made a significant impact.

The above discussion does not shed much light on the likely improvements in disability in the future, save to say, that the underlying prevalence of disability (at least over the last two decades) appears to be relatively stable. Any increases are likely to be the result of population ageing (AIHW 2000).

Despite this, it was decided to incorporate several sets of disability improvement assumptions in order to reflect a range of possible improvement scenarios in the future. Three scenarios are considered representing low (Series A), medium (Series B) and high (Series C) levels of disability improvement in the future. Before detailing the basis of each series, it is first necessary to discuss the modeling aspects of the improvements.

Incorporating improvements in the multiple state model may be achieved by introducing disability trends through varying transition intensities to and between core activity restriction states over time. Three modes of disability improvement are considered here.

6.2 Improvement in the Incidence of Core Activity Restriction

Improvements in the incidence of core activity restriction is perhaps the most obvious form of improvement. This was incorporated into the model in an analogous fashion to mortality improvement. That is:

$$New\_CAR_{x,t} = New\_CAR_{x,0} \cdot RF(x,t) \tag{23}$$

where $RF(x,t)$ is the reduction factor for age x at time t.

Again, the reduction factor, which provides for an exponential decrease in core activity restriction toward a limiting value, is given as:

$$RF(x,t) = \alpha(x) + [1-\alpha(x)] \cdot [1-f(x)]^{\frac{t}{20}} \tag{24}$$

where:

$$\alpha(x) = \begin{cases} c & x \le 65 \\ 1+(1-c)\cdot\dfrac{(x-110)}{65} & x > 65 \end{cases} \tag{25}$$

and:

$$f(x) = \begin{cases} h & x \le 65 \\ \dfrac{(110-x)h+(x-65)k}{65} & x > 65 \end{cases} \tag{26}$$

Note that the forms of $\alpha(x)$ and $f(x)$ are slightly different from the mortality analog in the model. The reason for this is that improvements in the incidence of morbidity are unlikely to be as great as in mortality (Nuttal et al. 1994).

A range of magnitudes for improvements in incidence were tested for sensitivity and the set shown in Table 8, for both males and females, was chosen.

Table 8: Core Activity Restriction Incidence Improvement Scenarios

Series	**Maximum Reduction in Incidence at 2051 (age 65)**	**Parameter *C***	**Parameter *h***	**Parameter *k***
A – Low	5.0 %	0.625	0.106	0.3
B – Med	10.0 %	0.600	0.197	0.3
C – High	15.0 %	0.566	0.272	0.3

That is, for Series A say, the probability of transition to a core activity restriction category at age 65 reduces gradually until 2051 when the probability of transition is equal to 95% of the probability in 1998.

The nature of the reduction factor (ie assumed exponential behaviour) does not allow a uniform improvement at all ages. That is, a set of parameters providing for a 5.0% reduction for persons aged 65 in 2051 will provide a lower percentage reduction for persons older than 65 and a higher percentage reduction for persons younger than 65. Note that this exponential behaviour was felt to be reasonable as it is expected that improvements and the very high ages are expected to be less likely than those at the earlier ages.

6.3 Improvements in the Severity of *New_CAR*

Transitions from the able category can be made to any of the core activity restriction categories. Thus, another form of core activity restriction improvement, is to reduce the likelihood of transitions to higher core activity restriction categories from an initially able state. This was implemented as follows:

$$f_{x,t} = f_{x,0} \times \beta^t \qquad (27)$$

where $f_{x,t}$ is as per equation (20) with age-time dependence.

A range of magnitudes for improvements in severity were tested for sensitivity and the set shown in Table 9 was chosen.

Table 9: Severity Improvement Scenarios

Series	β
A – Low	0.999
B – Med	0.998
C - High	0.997

6.4 Deterioration Improvements

The final form of core activity restriction considered is the situation where improvements occur in the deterioration from one core activity restriction category to a more severe core activity restriction category. This type of improvement is indeed feasible in reality if medical resources are targeted more specifically to persons who are already suffering from disability. The form of improvement is the same as that implemented in Walsh and Rickayzen (2000) and is represented as:

$$F(t) = 1 + [F(0) - 1] \times \alpha^t \qquad (28)$$

Again, a range of magnitudes for improvements in deterioration were tested for sensitivity and the set shown in Table 10 was chosen.

Table 10: Deterioration Improvement Scenarios

Series	α
A – Low	0.99
B – Med	0.98
C - High	0.97

The three scenarios considered representing low (Series A), medium (Series B) and high (Series C) levels of disability improvement in the future are summarised in Table 11 as follows.

Table 11: Projection Scenarios

Series	Maximum Reduction in Incidence at 2051 (age 65)	Severity Improvement	Deterioration Improvement
A - Low	5.0 %	$\beta = 0.999$	$\alpha = 0.99$
B – Medium	10.0 %	$\beta = 0.998$	$\alpha = 0.98$
C – High	15.0 %	$\beta = 0.997$	$\alpha = 0.97$

7.0 PROJECTION RESULTS AND ANALYSIS

7.1 Initial Checks

A basic check to ensure the general accuracy of the projection methodology is to essentially run the model with only two states – No Core Activity Restriction and Dead. This, in effect, is a straight population projection model and should thus produce estimates of future population in line with ABS estimates. A comparison is presented in Table 12.

Table 12: Projection Model Comparison with ABS (2000).

Population (000's)	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**
ABS – Males	9667.2	10600.0	11414.3	12052.7	12424.6	12625.8
Model – Males	9570.6	10491.7	11233.4	11813.7	12209.9	12469.2
ABS – Females	9754.1	10688.8	11512.1	12201.7	12609.0	12782.7
Model - Females	9652.2	10608.5	11381.6	11992.0	12372.2	12534.7
ABS – Total	19421.3	21288.8	22926.4	24254.4	25033.6	25408.5
Model – Total	19222.8	21100.2	22615.0	23805.7	24582.1	25003.9
Difference (%)	1.02%	0.89%	1.36%	1.85%	1.80%	1.59%
ABS – % aged 65+	12.13%	14.40%	18.53%	22.66%	25.39%	26.96%
Model – % aged 65+	12.40%	15.01%	19.30%	23.60%	26.49%	28.16%

Source: ABS (2000) Series II

Figure 4 shows that the estimates for the projected total Australian population through to 2051 appears consistent in shape with the ABS projections. Although the model estimates are slightly lower than those of the ABS, a maximum difference of under 2% over a 52 year projection period was felt to be acceptable. Any differences are explainable by virtue of a differing mortality improvement function as explained in Section 5.4. The treatment of migrants with respect to mortality as assumed in this model also impact the estimates.

Figure 4: ABS and Model Projections to 2051.

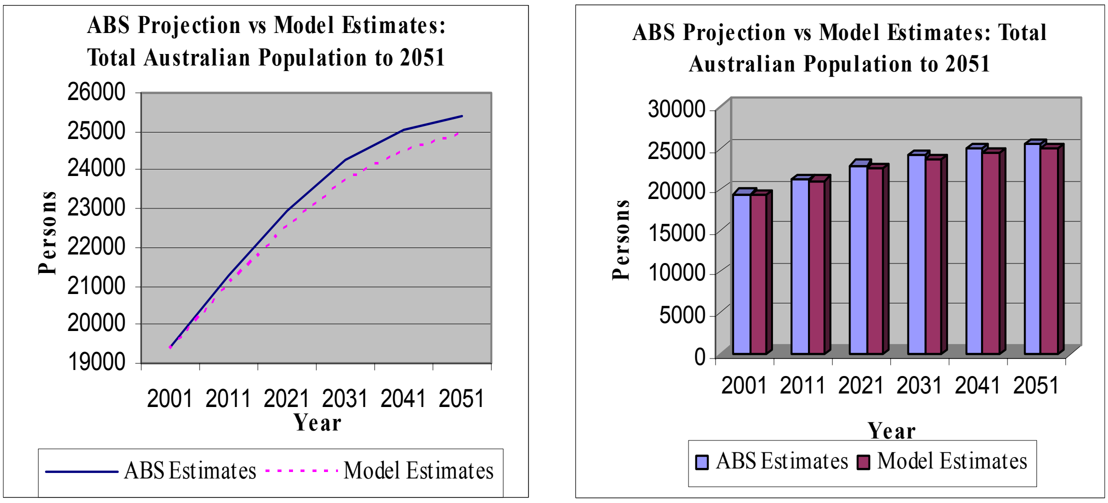
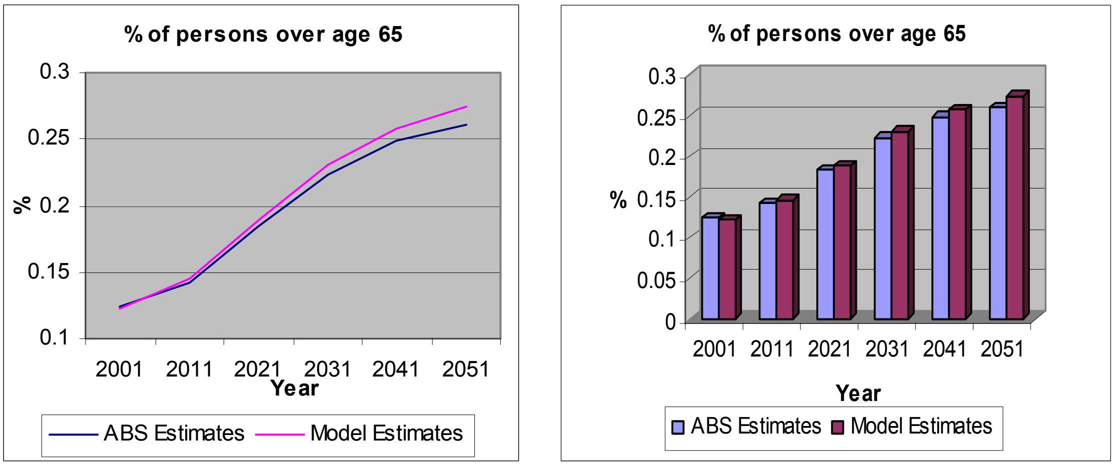


Figure 5(a)(b) ABS and Model Projections of % of Population Aged 65 and over to 2051



In addition, Figure 5 confirms that the model preserves the age structure of the population. The population in the higher ages are of particular concern given their connection with long term care.

Overall, the projection model is consistent with the ABS Series II projections.

7.2 Model Results

We now consider the full model. The following results outline the numbers of persons in each core activity restriction category by age and sex for each of series A-C which correspond to low, medium and high disability improvements respectively. An initial control set, series D, was also included for the situation of no disability improvement. That is, maximum reduction in incidence at 2051 of 0%, no severity improvement ($\beta = 1$) and no deterioration improvement ($\alpha = 1$).

A second control set (series E), which does not use the multiple state model but rather involves applying age and sex specific prevalence rates to the ABS Series II population projection, was also included. The Series was generated by multiplying the original disability prevalence rates to the projected population structure in future years. Again, this implies no disability improvement.

For both Series D and E, the same assumptions as in Section 5 of this paper are used.

7.3 Analysis of Results

We believe that deliberate attention should be directed, in particular, to the profound and severe core activity restriction categories. These categories are the most important in the context of long term care as acknowledged by other commentators such as Walsh and De Ravin (1995), Madge (2000) and AIHW (2000). Table 13 provides a more concise summary of the results.

Table 13: Number of Severe and Profound CAR: Series A-E vs AIHW Estimates

Male						
Series	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**
A – Low	511.9	586.1	686.7	814.4	938.7	1036.8
B – Med	511.2	573.9	654.5	756.1	852.1	922.9
C – High	510.4	561.8	624.1	702.8	755.6	824.8
D – Control	512.6	599.3	723.0	884.1	1047.0	1185.3
E – Control	536.6	651.1	768.8	916.4	1059.5	1177.4
AIHW	538.0	633.8	731.4	849.0	-	-
Female						
A – Low	631.7	727.9	857.3	1049.4	1242.6	1375.0
B – Med	630.8	713.2	820.2	982.1	1144.2	1249.4
C – High	629.9	698.9	785.3	920.8	1057.3	1141.1
D – Control	632.7	744.0	899.8	1130.8	1367.1	1540.0
E – Control	660.0	827.7	994.8	1223.5	1453.7	1611.4
AIHW	675.3	804.8	939.5	1134.8	-	-
Total						
A – Low	1143.6	1314.0	1544.0	1863.8	2181.3	2411.8
B – Med	1142.0	1287.1	1474.7	1738.2	1996.3	2172.3
C – High	1140.3	1260.7	1409.4	1623.6	1812.9	1965.9
D – Control	1145.3	1343.3	1622.8	2014.9	2414.1	2725.3
E – Control	1196.6	1478.8	1763.6	2139.9	2513.2	2788.8
AIHW	1213.3	1438.6	1670.9	1983.8	-	-

There is an inherent difficulty in checking for the reasonableness of the above output. Published estimates on the expected future numbers of persons in the various core activity restriction categories is limited. Walsh and De Ravin (1995) projected the future prevalence of profound and severe handicaps by using regression analysis to fit a log of log curve to the prevalence rates. Unfortunately, the prevalence rates they considered precede the current data set and thus their results are of limited use here.

Consideration of Table 15 reveals a reasonably close match between the results of the multiple state model, Series E and Australian Institute of Health and Welfare (AIHW) estimates. The AIHW, in their publication titled Disability and Ageing (2000) presented growth estimates for the future numbers of people with severe or profound core activity restrictions. These estimates are based on the same data set used in this model and thus provides the only basis upon which the results of this model may be checked. While the AIHW estimates are useful as a rough guide, caution must be taken as the AIHW projection period extends only to 2031 and there is no detailed description regarding the projection methodology used by the AIHW. A footnote reveals that the estimated numbers were calculated using age and sex specific prevalence rates applied to ABS (1998) Series K projection which was the basis for population growth. Note also that the AIHW estimates only consider the numbers of persons in the severe or profound core activity restriction category. The other categories are ignored. There is no mention in AIHW (1998) as to whether disability improvement is accounted for in their calculations. Thus, Series D and E may be the most comparable basis.

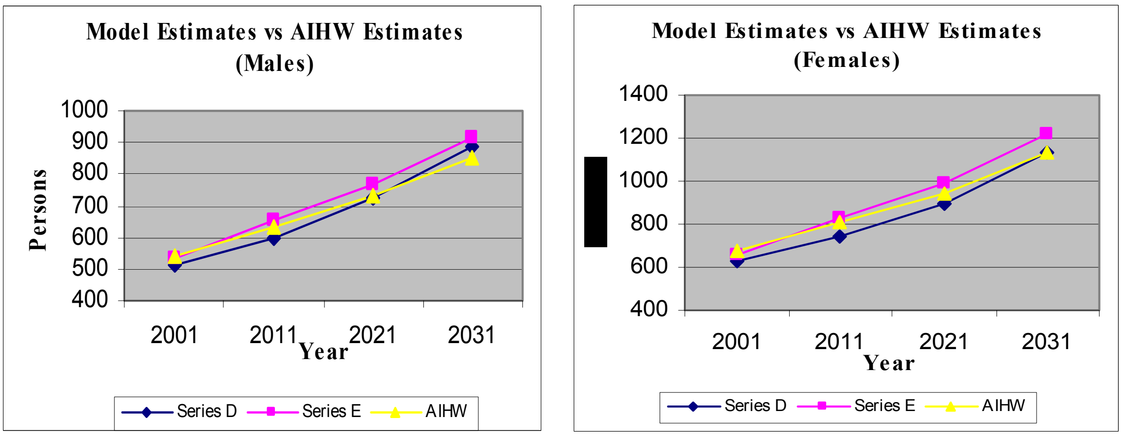
Table 14: Comparison of AIHW Estimates and Series D and Series E.

% Difference (absolute)	2001	2011	2021	2031
Totals Series D	5.60%	6.62%	2.88%	1.57%
Totals Series E	1.38%	2.79%	5.55%	7.87%
Males Series D	4.72%	5.44%	1.15%	4.13%
Males Series E	0.26%	2.73%	5.11%	7.94%
Females Series D	6.31%	7.55%	4.23%	0.35%
Females Series E	2.27%	2.85%	5.89%	7.82%

Source: Calculated from the Australian Institute of Health and Welfare (2000). Disability and Ageing.

Table 14 reveals that the model estimates for the total number of persons with severe or profound restrictions match AIHW estimates well - being consistently below a difference of 8% up to 2031. Both male and female model estimates also appear very much in line with AIHW estimates, at least until 2021, where differences begin to arise. Figure 6 shows a comparison of the model estimates for the number of persons with a profound or severe core activity restriction as compared with the AIHW estimates.

Figure 6: AIHW and model estimates for the number of persons with severe or profound CAR.



The total estimates appear to slightly underestimate the AIHW estimates until 2021 and slightly overestimate AIHW estimates beyond. In any case, given that all measured differences are within 8%, the model estimates are felt to be reasonable. Figure 7 illustrates the projected numbers of persons under each Series until 2051 for both males, females and the total population.

Figure 7 (a). Number of Severe or Profound Difficulties : Series A-E and AIHW: Males

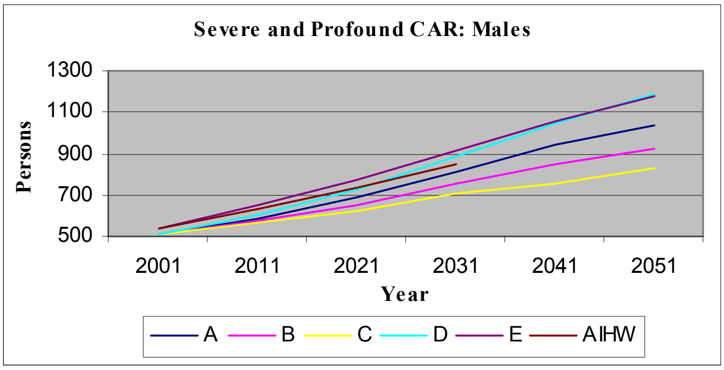


Figure 7 (b). Number of Severe or Profound Difficulties : Series A-E and AIHW: Females

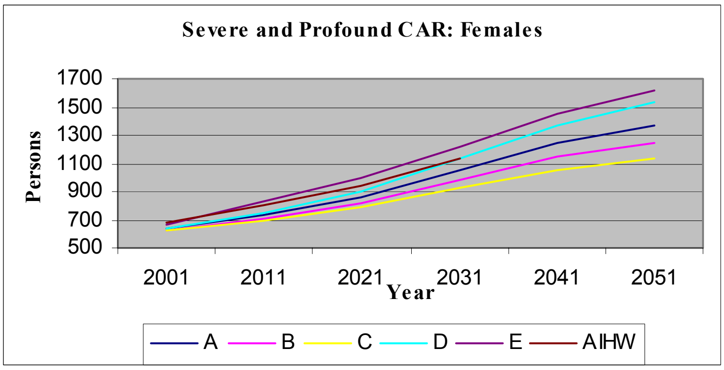
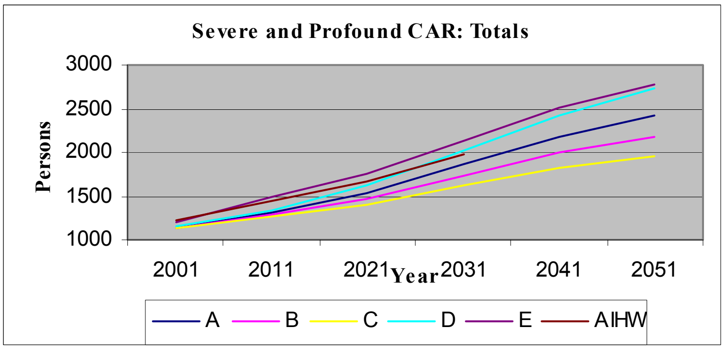


Figure 7 (c). Number of Severe or Profound Difficulties : Series A-E and AIHW: Totals



Given that LTC requirements are likely to most concern the elderly, a further consideration is to analyse the proportion of elderly persons suffering from severe and profound core activity restrictions.

Table 15 shows the number of persons afflicted with a severe or profound core activity restriction who are aged 65 and over.

Table 15: Number of Severe and Profound CAR aged 65+: Series A-E and AIHW Estimates.

			Male			
Series	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**
A – Low	181.0	255.0	350.6	483.8	616.4	722.7
B – Med	180.7	249.5	334.8	451.5	565.0	652.3
C – High	180.3	244.1	320.1	422.5	519.8	591.6
D – Control	181.4	261.6	369.9	525.0	684.7	819.7
E – Control	176.9	252.7	356.6	500.3	641.3	757.0
AIHW	177.0	233.9	315.6	424.6	-	-
			Female			
A – Low	328.3	411.5	527.9	721.6	923.1	1063.8
B – Med	327.7	403.6	507.5	680.7	860.0	981.7
C – High	327.1	396.1	488.5	643.9	804.4	910.5
D – Control	328.9	420.8	552.9	774.1	1007.3	1177.7
E – Control	330.7	452.4	602.1	830.7	1063.6	1222
AIHW	343.9	425.3	540.8	729.3	-	-
			Total			
A – Low	509.3	666.5	878.5	1205.4	1539.5	1786.5
B – Med	508.4	653.1	842.3	1132.2	1425.0	1634.0
C – High	507.4	640.2	808.6	1066.4	1324.2	1502.1
D – Control	510.3	682.4	922.8	1299.1	1692.0	1997.4
E – Control	507.6	705.1	958.7	1331.0	1704.9	1979.0
AIHW	520.9	659.2	856.4	1153.9	-	-

The model predictions for the number of persons with a severe or profound core activity restriction who are aged 65 and over are compared to AIHW estimates and presented in Table 16.

Table 16: Comparison of numbers of Severe and Profound CAR aged 65+: Series D and E vs AIHW Estimates

Series	2001	2011	2021	2031
AIHW Estimate 65+ (Total)	42.93%	45.82%	51.25%	58.17%
Series D Estimate 65+ (Total)	44.56%	50.80%	56.86%	64.47%
Series E Estimate 65+ (Total)	42.42%	47.68%	54.36%	62.20%
Difference in Total (%)- Series D	1.63%	4.98%	5.61%	6.30%
Difference in Total (%)- Series E	0.51%	1.86%	3.11%	4.03%

The differences are much in line with those for the total estimates. A maximum difference of 6.97% in 2031 for Series D appears reasonable taking into account model fitting difficulties.

Overall, the results from the multiple state model are reasonably consistent with both the Series E control set and available AIHW estimates. Although inevitable differences arise in the projections, this is clearly attributable to model fitting difficulties as already outlined.

The paper will now turn to considering the implications of these results to future costs of LTC in Australia.

7.4 Implications of Model Results to Future Costs of Long Term Care

Projecting the future costs of LTC is an inherently difficult task given that a complete and comprehensive picture of current costs is not available – especially in relation to home and community services where service requirements may be periodic and standard fees are non-existent. For instance, the costs for an individual's Home and Community Care (HACC) requirements are usually negotiated between the individual and their respective service providers. Furthermore, private contributions made by individuals or other charitable oranisations are also difficult to quantify. Ideally, unit costs for each separate HACC service would provide a more sound basis to estimate future costs. Both Madge (2000) and Allen Consulting Group (2002) acknowledge similar difficulties.

Given the paucity of relevant information when considering total LTC costs, it is possible that a simple 'top down' approach for determining future costs will be adequate for estimating future LTC expenditure. A similar approach has been employed by the European Union Economic Policy Committee (2001) in their health projections. That is, aggregate expenditures in a given year may be used to establish an average real expenditure per person (no disaggregation between sex and institutional or non-institutional care), and inflating this value in line with the projected number of persons requiring LTC (ie are either profoundly or severely restricted) as earlier forecasted by the multiple state model and associated control sets. That is, define LTC_b as total LTC expenditure in the base year (2002) and P_i to represent the total persons in age group i with a profound or severe restriction. Thus:

$$\mathrm{A} = \frac{LTC_b}{\sum_i P_i^b} \tag{29}$$

is the average real LTC expenditure per person. Future costs may therefore be simply determined as:

$$\overline{LTC_t} = \sum_i \overline{P_i^t} \times \mathrm{A} \tag{30}$$

where $\overline{LTC_t}$ and $\overline{P_i^t}$ are projected future costs of LTC and total persons in age group i with a severe or profound restriction in year t respectively.

While there are obvious deficiencies in this approach particularly in relation to segregation of costs according to institutional and non-institutional care, the absence of complete and detailed LTC cost data renders any improvements using more sophisticated methodologies arguably minimal.

Budgeted aggregate costs for 2002 were used here as they were the most recent costs available at the time of this paper. The costs, sourced from the 2002-2003 Commonwealth Budget are as follows: Residential costs - A$4,285 million, CACP - A$265 million, HACC - A$674 million, other – A$321 million. Moreover, a number of adjustments were made to these figures. Total residential costs were adjusted to reflect approximately 29% of total costs which are sourced from private funds (refer to AIHW 2001).Total HACC expenditure was increased to A$1 125 million to account for the 40% contribution of total HACC funding made by Australian States and Territories. Finally, informal contributions made by community organisations were included at a value of A$399 million (see Madge 2000).

The results of the LTC costs projection for each series produced by the multiple state model and the control sets are presented in Table 17.

Table 17: Estimated total LTC costs (constant 2002-2003 dollars A$ million)

Series	2011	2021	2031	2041	2051
Series A	9218	10832	13075	15303	16920
Series B	9030	10346	12194	14005	15240
Series C	8844	9888	11390	12718	13792
Series D	9424	11385	14135	16936	19119
Series E	10374	12372	15012	17631	19565

These results may be compared to three recent publications of estimated future aged care expenditure performed by McCallum (1998), Howe and Sarjeant (1999) and Madge (2000). McCallum's (1998) figures are based on New South Wales (NSW) recurrent expenditure data and adjusts the for non-governmental contribution for residential care but not other services. Informal care is not included in the projections. Howe and Sarjeant (1999) only consider residential care but include both recurrent and capital expenditure. Madge (2000) includes the same forms of expenditure as employed in this paper and uses a somewhat more detailed unit costs approach. Allen Consulting Group (2002) include both the same form of expenditure as employed in this paper plus capital expenditure.

A comparison between Series D (the multiple state model control set) and other published estimates is presented in Table 18.

Table 18: Comparison of Future LTC Costs

Estimate	2011	2021	2031	2041	2051
Series D (2002-2003 dollars)	9424	11385	14135	16936	19119
Madge (2000) (1996-1997 dollars)	7 009	9 818	13 139	-	-
McCallum (1998) (1994 – 1995 dollars)	6 603	7 684	9 880	13 210	15 815
	2008	**2018**	**2028**	**2038**	**2048**
Howe and Sarjeant (1999) (1998-1999 dollars)	7 003	8 595	11 651	15 698	18 902
		2020			
Allen Consulting Group (2002) (2001-2002 dollars)	-	12 092.6	-	-	-

As seen in Table 18, given different base years and different projection methodologies, the estimates are generally comparable. The results of this study, and others, reveal an obvious and steep escalation in the costs of LTC to a level of approximately A$ 19 billion. This also represents an overall increase in LTC expenditure as a percentage of GDP. Table 20 reveals the growth of total LTC expenditure (series D) as a percentage of forecast GDP.

Table 20: Projected LTC expenditure as a percentage of GDP.

	2011	2021	2031	2041	2051
GDP (A$mil)	591 270	697 680	815 780	959 440	1 130 270
% GDP	1.17%	1.20%	1.27%		
Madge (2000)	0.99%	1.19%	1.38%	-	-
		2020			
Allen Consulting Group (2002)	-	1.84	-	-	-

Source: GDP forecasts sourced from Clare et al, *Australia's Ageing Society*, Office of Economic Planning and Advisory Council (EPAC), Background Paper No. 37, 1994 ; GDP deflator sourced from World Bank Tables Database, Econdata, Series 24642, July 2002 The World Bank, USA.

Clearly the magnitude of LTC expenditure in the future represents an important challenge to both government and industry. The implications of these results impact directly upon whether the Commonwealth are able to financially sustain such increases and whether alternative funding mechanisms such as private or social insurance may be required to meet these future obligations.

8.0 MODEL LIMITATIONS AND FUTURE SCOPE

The results of this study are qualified by a number of limitations.

8.1 Data

A number of limitations may be associated with the data used in this investigation. The primary data source in this investigation is the Survey of Disability, Ageing and Carers conducted by the ABS in 1998. This was an extensive survey involving categorising persons according to core activity restriction. This process of assignment is complex and thus peculiarities and errors are inevitable. Moreover, given that the data is segregated according to thirteen age groups and core activity restriction categories, a degree of random error is expected.

Perhaps a more important limitation of the data is the grouping, by the ABS, of persons aged 85 and over. It is quite likely that prevalence rates for persons aged in their late 90's are much higher than for those in their 80's. Consequently, the transition dynamics at the very old ages are not able to be captured by the model. The impact of this limitation is perhaps not so extreme given that only a small proportion of the total population are in the very high age categories. This, may well be an issue, however, in the future.

Data relating to costs for LTC also impose limits on the results of this study. As mentioned, no comprehensive set of cost data is available for home and community based LTC services. Although Madge (2000) makes some ground on estimating these unit costs, he concedes that the task is indeed difficult given paucity of data and qualifies his own figures as indicative of simply 'an order of magnitude'.

8.2 Methodology

The multiple state model also suffers from a number of limitations. A limitation is the fit of the model and its inability to exactly match ABS prevalence rates. The transition probabilities are determined to initially match published prevalence rates. Thus, any deviation will result in an immediate degree of error which will inevitably carry through to projections. Future research may be directed to achieving closer matches to initial prevalence rates - an obvious avenue being an examination of alternative functional forms for transition probabilities, investigating alternative best fit statistics or investigating alternative model fitting procedures.

Several other aspects of the model are subject to limitation and may provide scope for future research. The full complement of improvements has not been included in this model and future research may be aimed at extending the range of improvement transitions. Finally, the model does not allow for duration and thus the probability of a transition is assumed to apply equally regardless of how or when a person arrived in a particular state. Further consideration may be given to allowing for duration in the model.

9.0 CONCLUSIONS

The problem of determining future LTC needs and costs in Australia is highly topical and thus consideration of this issue is not isolated to this paper. This paper seeks to contribute to the discourse in Australia through the use of alternative projection methodologies – in this case a multiple state modeling approach.

The model implemented here has several advantages over previous models. Perhaps the most notable being increased flexibility, allowing the investigation of both different disability improvement or deterioration scenarios and a range of different projection assumptions. Furthermore, the multiple state modeling framework may be further pursued in other research concerning LTC such as pricing private insurance contracts.

The overall conclusion of the paper is a general consistency in prediction with other published estimates which should further stimulate increased government, industry and public awareness of the issue and provide an impetus for addressing the problem.

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