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Balance of Care in an Ageing Society: Construction of the BCASO microsimulation model

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Summary

We describe the construction and validation of a dynamic discrete-time microsimulation model of older people and their consumption of health and social care. The model was designed to be used in testing policy scenarios particularly related to the balance of aged care.

Individual-level data from two series of 5-yearly New Zealand national health and disability surveys respectively spanning the period 1996 to 2006 were used to inform the model. In particular the influence of long-term illness and disability (as well as socio-demographic factors) on levels of health and social care use respectively was assessed and incorporated in the model.

We were able to build a working model of older people and aged care which approximated actual benchmark data.

Such a model can provide a useful representation of social reality and enable scenario testing with implications for policy decision-making.

1. Introduction

As in other developed countries, the demographic composition of New Zealand is changing as birth rates decline and as life expectancy steadily increases *(Robine and Michel 2004)*. The result is to greatly expand the proportion of the population aged 65 years or older, the sub-group most likely to experience long-term illness and disability, and to require health and social care *(Christensen et al. 2009*). This shift in age structure - and the rise of chronic diseases - has major implications for the provision of services and other supports for older people *(Knickman and Snell 2002; Oxley 2009; Rechel et al. 2009)*. Yet the extent of future morbidity and disability, and the concomitant care needs of older people remain unclear *(Graham et al. 2004; Jagger et al. 2006; Lloyd-Sherlock et al. 2012; Spijker and MacInnes 2013)*. Nevertheless, there is pressure on available resources to keep pace with the sheer increase in the volume of care required with ever larger numbers of older people *(Appleby 2013, McNeil and Hunter 2014)*. The policy challenges posed by demographic ageing require the assessment of alternative options, one of which is to change the balance of care *(Audit Scotland 2014; Coyte et al. 2008; Tucker et al. 2013)* towards more efficient and effective configurations *(SBC Delivery Group 2009; Wanless et al. 2006)*.

Such complex policy issues require methods that enable research synthesis and utilise systems thinking *(Milne et al. 2014)*. To test policy options related to health and social care use, the technical approach we adopt here is microsimulation *(Anderson and Hicks 2011; Rutter et al. 2011; Zaidi, Harding and Williamson 2009; Zucchelli, Jones and Rice 2012)* which has been used, for example, to assess the impact of demographic ageing on population health *(Gupta and Harding 2007)* and on the future need for care *(Ministry of Health & Social Affairs, Sweden 2010)*. Empirically anchored, this type of model can account for social complexity and the heterogeneity of social groups. Microsimulation relies on data from the real world to create an artificial replicate upon which virtual investigations can be conducted *(Spielauer 2011)*. It operates at the level of individual units (here older people), each with a set of attributes as a starting point - for example, age and health state - to which quantitative rules are applied to simulate changes in state or behaviour. This model essentially combines information and generates a set of representative synthetic later life histories. The model can then be used to test hypothetical scenarios by artificial modification of key influential factors and assessment of impact on outcomes of policy interest, for example, older people's primary health service use *(Davis, Lay-Yee and Pearson 2010)*.

In this technical paper, we describe the construction and validation of a microsimulation model of health and social care use among older people in New Zealand. The model was designed both for projections - that is, the impact of demographic ageing under current settings to 2021 - and for policy scenario testing, for example, 'what if' questions regarding the balance of care. Our model provides a virtual laboratory that can be used to understand social processes or for preliminary assessment of the likely effect of alternative policy options under conditions of demographic ageing.

2. Aims

The overall aim of the study was to model the future shape of health and social care in New Zealand under demographic ageing, using a microsimulation approach. We focused on older people aged 65 years and over with the base year being 2001, and the period extending out to 2021.

2.1 Research questions

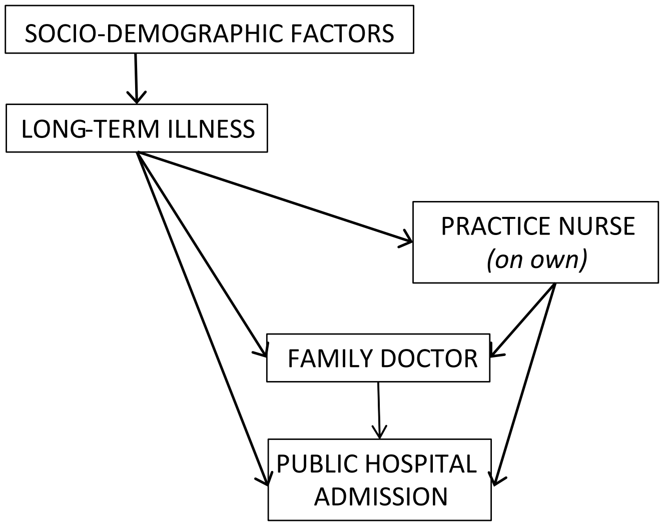
(1) What will be the future levels of health and social care use for older people under the status quo? This is our 'base projection'.
(2) What is the impact of reducing morbidity and disability levels - mimicking healthier ageing - on use of health and social care for older people? This is our 'morbidity or disability scenario'.
(3) What is the impact of changing the balance among providers on levels of health and social care use for older people? This is our 'care scenario'.

We built upon our earlier static microsimulation model - Primary Care in an Ageing Society (PCASO) – which centred on recent illness, general practitioner (GP) use and GP activity, in the population *(Davis, Lay-Yee, and Pearson 2010; Lay-Yee et al. 2011; Pearson et al. 2011)*. Here, in the BCASO model (Balance of Care in an Ageing Society), we conceptualised two separate modules: for 'health care' and 'social care' respectively.

2.2 Health care module

The model comprised long-term illness (condition-based) - and imputed disability (based on level of assistance used in daily living) - and concomitant health care (practice nurse, family doctor (GP), public hospital admission) (see Figure 1). The model was hierarchically structured - with long-term illness driving health care use, with practice nurse use affecting family doctor use and public hospital admission, and with family doctor use affecting public hospital admission - and dynamic in that it incorporated change over time.

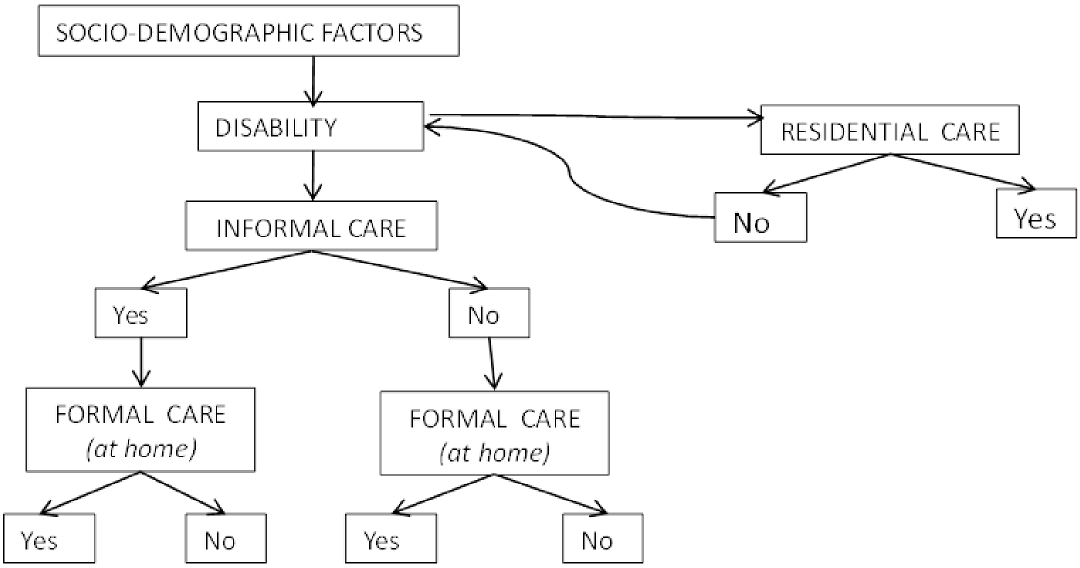
Figure 1 Conceptual model of late-life ageing and health care trajectory



2.3 Social care module

The model comprised disability (based on support levels), and associated social care (informal, formal or residential components) (see Figure 2). The model was hierarchically structured: disability level, adjusted for socio-demographic factors, drives social care use; informal care use affects formal care use; and residential care is linked to community care. It is also dynamic in that it incorporated change over time.

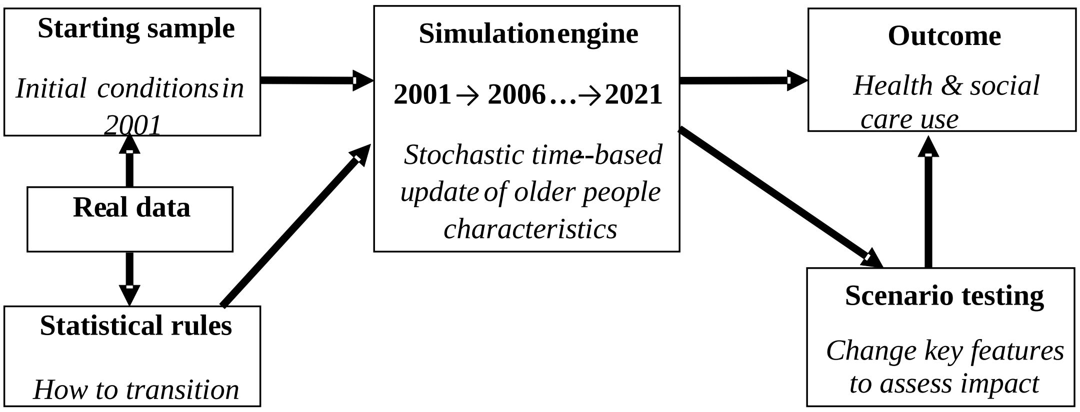
Figure 2 Conceptual model of late-life ageing and social care trajectory



3. Methods

We constructed a dynamic discrete-time microsimulation model *(Li and O'Donoghue 2012)* of morbidity and disability, and concomitant health and social care use over time (Figure 3) based on empirical data from a New Zealand sample of older people.

Figure 3 The microsimulation model



3.1 Study design

To build a realistic and representative model, we used data from national repeated cross-sectional surveys *(Martini and Trivellato 1997)*. We derived quantitative rules from these data to drive the simulation, thus ageing the starting cohort and so creating a virtual cohort composed of synthetic but representative life histories. Different policy-relevant scenarios could then be posed by altering features of the model to assess the likely effects on an outcome of interest. Data manipulation and analysis were carried out using SAS *(SAS Institute)*. Model implementation was programmed in R *(R Development Core Team 2011)* producing our 'BCASO-Simario' package.

The process of constructing and implementing the model followed several stages *(Cassells, Harding and Kelly 2006; Zaidi and Rake 2001)*:

(1) design simulation processes to mimic actual pathways to social care use;
(2) establish the starting sample;
(3) undertake analysis on available data to derive equations related to time-variant social care use;
(4) beginning with the starting sample, apply equations to stochastic simulation processes to drive change in individual states and behaviour;
(5) validate the results of simulation processes and outcomes against benchmarks; and
(6) design and test various scenarios by varying relevant factors.

3.2 Data sources

We harmonised and combined individual-level data on older people aged 65 years and over from two series of the 5-yearly New Zealand Health Survey (NZHS) *(Ministry of Health NZ 1999, 2004, 2008)* and Disability Survey (NZDS) *(Statistics NZ 1999, 2002, 2009, 2013)* respectively. As well as the person's demographic characteristics (from NZHS), there was information on whether they had a long-term illness (from NZHS) or disability (from NZDS), and on their use of health care (from NZHS) or social care (from NZDS). These survey data had the advantage of being nationally representative and recent, with reasonable sample sizes.

We employed these data sources in the following ways:

(1) To form a starting sample at the base year (circa 2001) that provided initial conditions representative of older people (aged 65 years and over) living in the community ('householders') or in residential care facilities ('residents'). The NZHS (2002) contributed data on 2,206 householders; disability level was imputed to these individuals from a multinomial model using in-common socio-demographic variables from NZDS (2001) data (see Appendix, Tables A1-A3). The NZDS (2001) also contributed data on 601 residents. A description of characteristics of the starting sample can be found in Table 1.

(2) To derive statistical equations from cross-sectional data to inform dependencies and outcomes within any year. The NZHS (2002) was used to model health care use. The NZDS (2001) was used to model social care use.

(3) To derive transition probabilities from repeated-cross-sectional data to inform dynamic changes from year to year. The NZHS data (2002 and 2006) were used to estimate transition probabilities for long-term illness, and partnership status. The NZDS data (1996 and 2001) were used to estimate transition probabilities for disability level, and residential care status. The survey years chosen for comparison were dictated by the availability and compatibility of variables between them.

(4) To provide 2006 empirical benchmarks against which to compare the simulated results of running the model from the base 2001.

Table 1 Description of starting sample. Characteristics of older people aged 65+ years living in various settings, 2001.

	Percentage of weighted sample [a]		
	Householders only (n=2206)	**Residents Only (n=601)**	**Householders and Residents (n=2807)**
Age Group			
65-74	54.2	16.9	51.9
75-84	36.5	35.2	36.4
85+	9.3	47.9	11.7
Gender			
Female	55.3	70.6	56.3
Ethnicity			
European	91.8	86.6	91.5
Māori	4.0	1.5	3.8
Pacific	1.7	1.8	1.7
Asian	2.2	0.7	2.1
Other	0.3	9.5	0.9
Marital status			
Partnered	56.5	19.6	54.2
Deprivation decile			
1 (low deprivation)	6.5	-	-
2	7.6	-	-
3	9.3	-	-
4	10.4	-	-
5	10.1	-	-
6	13.5	-	-
7	10.6	-	-
8	13.8	-	-
9	11.1	-	-
10 (high deprivation)	7.3	-	-
Long-term illness			
Present	85.6	-	-
Disability level [b]			
None	49.1	0	46.0
Mild	14.7	0	13.8
Moderate	27.7	18.4	27.1
Severe	8.5	81.6	13.1

a. The starting sample was taken from the New Zealand (NZ) Health Survey 2002 (Ministry of Health 2004), and the NZ Disability Survey 2001 (Statistics NZ 2002), with weighting calibrated to the NZ Census 2001.
b. Imputed from NZ Disability Survey 2001.

3.3 Definition of variables

The variables employed in the model can be categorised into five types:

(1) Socio-demographic

- Age: 65+ years.
- Gender: male, female.
- Ethnicity (prioritised): Māori, Pacific, European, other.
- Socio-economic deprivation: 'NZDep' decile *(Salmond and Crampton 2012)*.
- Partnership (yes/no).

(2) Morbidity

- Long-term illness (yes/no).

(3) Disability

- Disability level - none, mild, moderate, and severe (yes/no) - corresponding to required levels of assistance in daily living - none, some, and every day respectively.

(4) Health care (outcomes)

- Health service use: practice nurse (yes/no); family doctor (GP) visit categories – 0, 1-2, 3-4, 5-6, 7+ (yes/no); public hospital admission (yes/no).

(5) Social care (outcomes)

- Social care: informal – provided at home by family or friends (yes/no), formal – provided at home by government or other agencies (yes/no), residential (yes/no).

3.4 Analysis

We analysed data from the NZHS and NZDS series to derive parameters – statistical equations and transition probabilities - for time-variant outcomes of interest to inform the simulation process. We used regression models to estimate values of coefficients for significant observed predictors from cross-sectional data, and matrices to estimate transition probabilities from repeated cross sections. We outline in general the analyses undertaken for the two respective modules (for 'health care' and 'social care') before describing specific details of the calculation and verification of transition probabilities.

3.4.1 Health module

We used the NZHS cross-sectional data (2002) to predict health care outcomes using a set of available variables including: long-term illness, age, gender, ethnicity, deprivation, and partnership. We decided on a hierarchical structure for the overall model so that earlier events or states could exert an influence over later ones (Figure 1). For example, the presence of long-term illness could affect the level of use of practice nurses which could in turn affect the need for and use of family doctors. The health care regression models showing significant predictors were as follows:

- [Logistic] Practice nurse use (yes/no) ~ long-term illness, age, gender, ethnicity (see Appendix, Table A4).
- [Multinomial] Family doctor use (high user group: 5+ visits per year) ~ practice nurse use, long-term illness, age, gender, ethnicity, partnership (see Appendix, Table A5).
- [Logistic] Public hospital admission (yes/no) ~ family doctor use, practice nurse use, long-term illness, age (see Appendix, Table A6).

We assumed that the level of long-term illness and disability, reflecting need, were the prime drivers of health care use. Therefore transition probabilities for these factors were first estimated from matrices using repeated cross-sectional data (from NZHS and NZDS) – depending on age and gender. These results then flowed through to impart dynamism to subsequent cross-sectional models of different health care modalities. Transition probabilities were also estimated for partnership status (from NZHS), but not for deprivation level (NZDep decile) due to lack of information and intractable matrix equations (so assumed to be stable for 65+ year-old people).

3.4.2 Social care module

We used the NZDS cross-sectional data (2001) to predict social care outcomes using a set of available variables including: disability level, age, gender, ethnicity, deprivation, and partnership. We decided on a hierarchical structure for the overall model so that earlier events or states could exert an influence over later ones (Figure 2). For example, the level of disability could affect the level of use of informal care which could in turn affect the need for formal care. The social care logistic regression models showing significant predictors were as follows:

- [Logistic] Informal care (yes/no) ~ disability, age, gender, ethnicity, deprivation (see Appendix, Table A7).
- [Logistic] Formal care (yes/no) ~ informal care, disability, age, gender, ethnicity (see Appendix, Table A8).

Residential care status at baseline was assigned deterministically according to the original NZDS (2001) data source.

We assumed that the level of disability, reflecting need, was the prime driver of social care use, and so transition probabilities were first estimated from matrices using repeated cross-sectional data (from NZDS) – depending on age and gender. Then second, these results flowed through to impart dynamism to subsequent cross-sectional models of different social care modalities. Transition probabilities were also estimated for partnership status (from NZHS), and for those living in the community moving into residential care facilities (from NZDS). Deprivation level was considered to be stable for this older group.

3.4.3 Transition probabilities

In the absence of longitudinal data that would provide repeated measures of health or disability state on the same person, we estimated transition probabilities using repeated cross-sectional survey data *(Walker 2003)*. Matrix models were employed but to make solutions tractable the following basic assumptions were required:

- 'One-way traffic', e.g. once disabled always disabled (no recovery).
- Steady progression - one step at a time, e.g. from mild to moderate disability, and then from moderate to severe disability.

Age group and gender were selected as being the important predictors of long-term illness and disability; other variables were not considered either because there were low sub-group numbers, e.g. ethnicity, or they were not time-invariant, e.g. partnership status.

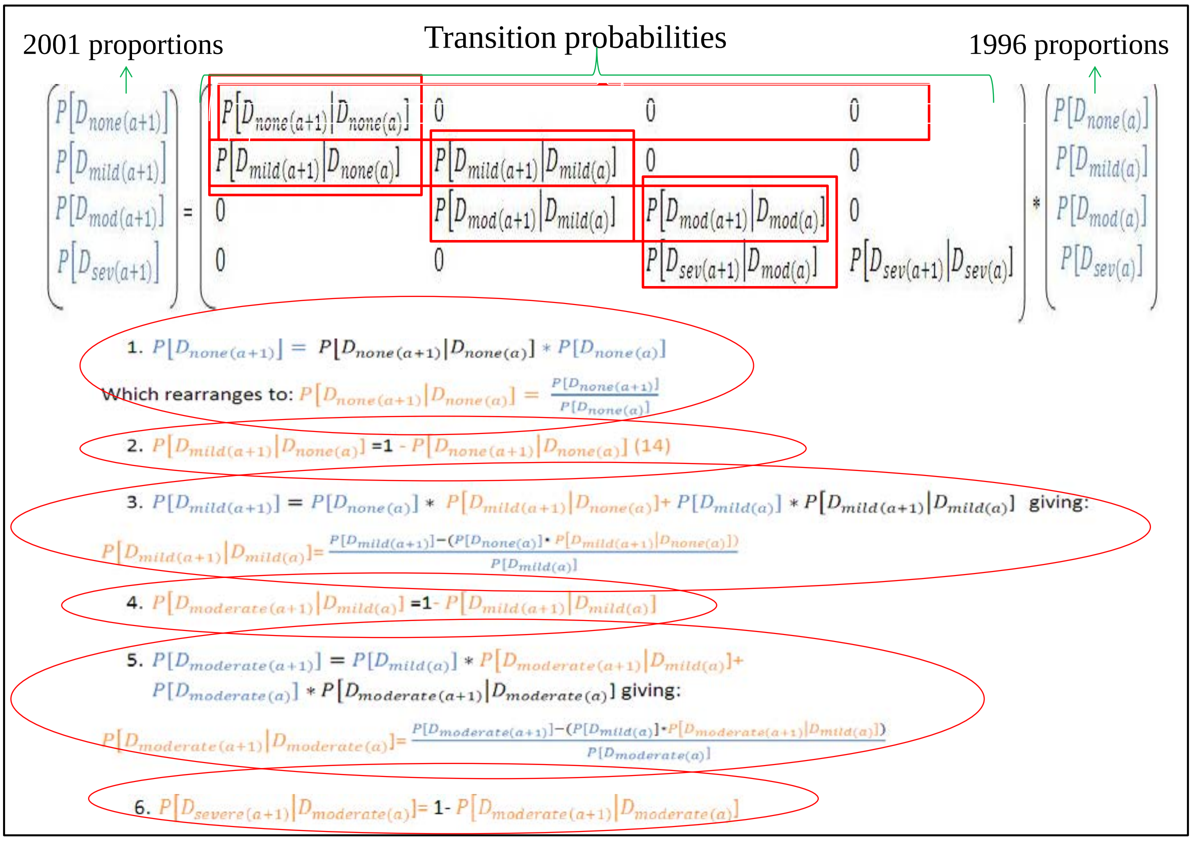
We developed a search strategy to find the correct combination of matrix entries given the 'one-way' and 'one-step-at-a-time' rules. In some instances, it was necessary to relax the assumptions to accommodate potential bi-directional and/or multi-step changes in state. The searching strategy involved trial and error to find a plausible set of probabilities that avoided nonsensical probabilities (negative and corresponding greater-than-one values). The success criteria were whether equation results were consistent with one another and whether the results gave good internal validation.

3.4.3.1 Transition probabilities: Disability level

We assumed that the level of disability, reflecting need, was the prime driver of social care use. Therefore disability level was first estimated dynamically with the results then flowing through to subsequent models of different care modalities (Figure 2).

For disability level, a matrix of probabilities was set up, given the starting 1996 and ending 2001 proportions and following the 'one-way' and 'one-step-at-a-time' rules (Figure 4). Thus certain cells could be assigned probability values of ‘0’ and ‘1’ and a searching algorithm employed to solve the remaining cell entries.

Figure 4 Disability level – matrix and equations



We estimated transition probabilities using repeated cross-sectional survey data. We matched as best we were able on time-invariant variables present in both surveys to produce a pseudo-cohort across the repeated years. To calculate the 5-year transition probabilities for disability level, temporary copies of the NZDS 1996 and 2001 surveys were used. The time-invariant variables used were ‘age group in 1996’ and ‘gender’. Both data sets were limited to those people who were 65+ years of age. An age group variable (consisting of categories 65-69, 70-74, 75-79, 80-84, 85+) was created in each data set. A ‘back-casted’ age was then created for those in the NZDS 2001 data set, giving what their age group would have been 5 years earlier. This was so that groups of individuals, defined by their age and gender categories, could be approximately matched across the two time periods (1996 and 2001) in order to see how the proportion of people at each disability level changed for a given age group and sex cohort in 1996 over the 5 years to 2001. Records that had a back-casted age of ‘60-64’ in 1996 were deleted, as we were trying to get transition probabilities for 65-69 year olds in 1996 moving forward to 2001. The disability variable – originally just one variable giving the level of severity of disability - was also split into four indicator variables – one for each of the four levels (none, mild, moderate, and severe).

3.4.3.1.1 Transition probabilities: Disability level – estimation procedure

Steps in the procedure were:

(1) In order to make the two data sets closer to representing the same people as much as possible, 5-year probabilities of death by age and gender from New Zealand life tables *(Statistics NZ, http://www.stats.govt.nz/browse_for_stats/health/life _expectancy.aspx)* - adjusted by whether they were in residential care or not, and if not, by their disability level *(Statistics Canada 2008)* - were applied to the 1996 data. We only had death probabilities available for people up to 96 years of age. If a person was older than 96, then we applied the death probability for a 96-year old. Records for individuals likely to die by the year 2001 were deleted from the data set before matching to the 2001 data.

(2) Separate transition probabilities for disability level were required for those that started out in 1996 as householders, and for those that started out in residential care in 1996 (so that there would be a link between residential-care status and disability level over time in the simulation). To do this we split both the 1996 and the 2001 data sets into a residential-care set and a non-residential-care set, such that we could match across the years also on this variable, i.e. residential-care status in 1996. To split the 2001 data into the two subsets we assumed that those people who were householders (i.e. not in residential care) in 2001, were, looking backwards in time, householders in 1996 (this refers to the assumption that once in residential care, people stay in residential care, i.e. they cannot become householders in the future). For the people that were in residential care in 2001, we ascertained if they had been in residential care back in 1996. To do this we used their responses to the survey question that asked how long they had spent in residential care. We chose to assign everyone who reported 'less than 6 years' as being in residential care in 1996 (5 years earlier).

(3) Survey-weighted numbers of people in each disability level in the 1996 survey were calculated both for householders and residents by age group and gender. The same was undertaken for the 2001 survey though separately for those assigned as being a householder or resident in 1996, and by 'age group in 1996' and gender. These data were then merged together by 'age group in 1996' and gender, generating a pseudo-cohort that provided an estimate of how the number of people with each level of disability changed over time in each age –and-gender group.

(4) The proportion in each disability level in each year and age-group-gender cell was calculated, and then the transition probabilities from each state in 1996, to each state in 2001, were estimated using matrix algebra (see below).

3.4.3.1.2 Transition probabilities: Disability level – Matrix methodology

In order to model the disability state transitions, we assumed the 'one-way' and 'one-step-at-a-time' rules which make sense for the older population that we are modelling. A matrix representation of the system we are trying to model is given below, e.g. for householders (Figure 5). 'P' stands for 'probability' in the four-column matrix in the middle, or 'proportion' in the two one-column vectors at the sides, and 'D' stands for 'disability level'. The standalone column on the right side gives the proportion in each disability level in the prior time period (period 'a' – e.g. when a person may be 65-69 years old) ,and the other standalone column on the left side gives the proportion in each disability level for the future time period (period 'a+1' – e.g. when the same person who was 65-69 years old in period 'a' is now 70-74 years old in period 'a+1'). Both these sets of proportions are known from the data: 1996 (period 'a') and 2001 (period 'a+1'). The four-columned matrix in the middle contains the conditional transition probabilities that we are trying to estimate. The 'one-way' and 'one-step-at-a-time' assumptions are mathematically represented in this block of transition probabilities by the zero cells – these zero cells in turn allow the set of matrix equations to become tractable, so that we can estimate the unknowns.

Figure 5 Disability level – matrix

$$\begin{bmatrix} P[D_{none(a+1)}] \\ P[D_{mild(a+1)}] \\ P[D_{mod(a+1)}] \\ P[D_{sev(a+1)}] \end{bmatrix} = \begin{bmatrix} P[D_{none(a+1)}|D_{none(a)}] & 0 & 0 & 0 \\ P[D_{mild(a+1)}|D_{none(a)}] & P[D_{mild(a+1)}|D_{mild(a)}] & 0 & 0 \\ 0 & P[D_{mod(a+1)}|D_{mild(a)}] & P[D_{mod(a+1)}|D_{mod(a)}] & 0 \\ 0 & 0 & P[D_{sev(a+1)}|D_{mod(a)}] & P[D_{sev(a+1)}|D_{sev(a)}] \end{bmatrix} * \begin{bmatrix} P[D_{none(a)}] \\ P[D_{mild(a)}] \\ P[D_{mod(a)}] \\ P[D_{sev(a)}] \end{bmatrix}$$

Given our assumptions, we can use the equalities implied in each row, and also in each column, to give us a cascade of equations that enable us to calculate the unknown probability terms – see below. We call it a cascade of equations as terms that are derived earlier on in the sequence of equations fed into later equations, which then go on to derive more terms. These equations are applied separately for each age-gender group. The equations will hold only if the assumptions made are correct and borne out in the data. If not, then the equations will produce invalid probabilities – either ones that are negative or not within the allowable range (0 - 1).

The first row gives:

- $P[D_{none(a+1)}] = P[D_{none(a+1)}|D_{none(a)}] * P[D_{none(a)}]$ (1a)
- Which rearranges to: $P[D_{none(a+1)}|D_{none(a)}] = \frac{P[D_{none(a+1)}]}{P[D_{none(a)}]}$ (1b)

  where $P[D_{none(a+1)}]$ and $P[D_{none(a)}]$ are estimated from the proportions in the NZDS 1996 and 2001 that had 'no disability' in the ages represented by 'a+1', and in the ages represented by 'a' respectively.

The second row gives the following two unknown terms:

- $P[D_{mild(a+1)}|D_{none(a)}]$ (2)
- $P[D_{mild(a+1)}|D_{mild(a)}]$ (3)
- Which together must satisfy: $P[D_{mild(a+1)}] = P[D_{none(a)}] * P[D_{mild(a+1)}|D_{none(a)}] + P[D_{mild(a)}] * P[D_{mild(a+1)}|D_{mild(a)}]$ (4)

The third row gives the following two unknown terms:

- $P[D_{moderate(a+1)}|D_{mild(a)}]$ (5)
- $P[D_{moderate(a+1)}|D_{moderate(a)}]$ (6)
- Which must satisfy: $P[D_{moderate(a+1)}] = P[D_{mild(a)}] * P[D_{moderate(a+1)}|D_{mild(a)}] + P[D_{moderate(a)}] * P[D_{moderate(a+1)}|D_{moderate(a)}]$ (7)

The final row gives:

- $P[D_{severe(a+1)}|D_{moderate(a)}]$ (8)
- $P[D_{severe(a+1)}|D_{severe(a)}]$ (9)
- Which must satisfy: $P[D_{severe(a+1)}] = P[D_{moderate(a)}] * P[D_{severe(a+1)}|D_{moderate(a)}] + P[D_{severe(a)}] * P[D_{severe(a+1)}|D_{severe(a)}]$ (10)

We also have the columns – i.e. the probabilities must also satisfy:

- $P[D_{none(a+1)}|D_{none(a)}] + P[D_{mild(a+1)}|D_{none(a)}] = 1$ (11)
- $P[D_{mild(a+1)}|D_{mild(a)}] + P[D_{moderate(a+1)}|D_{mild(a)}] = 1$ (12)
- $P[D_{moderate(a+1)}|D_{moderate(a)}] + P[D_{severe(a+1)}|D_{moderate(a)}] = 1$ (13)
- $P[D_{severe(a+1)}|D_{severe(a)}] = 1$ (14)

From (1b) and (11) above we can then derive:

- $P[D_{mild(a+1)}|D_{none(a)}] = 1 - P[D_{none(a+1)}|D_{none(a)}]$ (15)

From (4) and (15) we then have:

- $P[D_{mild(a+1)}] = P[D_{none(a)}] * P[D_{mild(a+1)}|D_{none(a)}] + P[D_{mild(a)}] * P[D_{mild(a+1)}|D_{mild(a)}]$ giving:
- $P[D_{mild(a+1)}|D_{mild(a)}] = \frac{P[D_{mild(a+1)}] - (P[D_{none(a)}] * P[D_{mild(a+1)}|D_{none(a)}])}{P[D_{mild(a)}]}$ (16)

From (12) and (16) we can then derive:

- $P[D_{moderate(a+1)}|D_{mild(a)}] = 1 - P[D_{mild(a+1)}|D_{mild(a)}]$ (17)

From (7) and (17) we have:

- $P[D_{moderate(a+1)}] = P[D_{mild(a)}] * P\left[D_{moderate(a+1)} \middle| D_{mild(a)}\right] + P[D_{moderate(a)}] * P\left[D_{moderate(a+1)} \middle| D_{moderate(a)}\right]$ giving:
- $P\left[D_{moderate(a+1)} \middle| D_{moderate(a)}\right] = \frac{P[D_{moderate(a+1)}] - (P[D_{mild(a)}] * P\left[D_{moderate(a+1)} \middle| D_{mild(a)}\right])}{P[D_{moderate(a)}]}$

(18)

From (13) and (18) we can then derive:

- $P\left[D_{severe(a+1)} \middle| D_{moderate(a)}\right] = 1 - P\left[D_{moderate(a+1)} \middle| D_{moderate(a)}\right]$

Finally, we also have:

- $P\left[D_{severe(a+1)} \middle| D_{severe(a)}\right] = 1$

On applying these equations, it was found that the assumptions must not have held in all cases, as we were getting some negative and greater-than-one probabilities.

In order to remedy this, we had to relax the assumptions a little – in some cells needing to replace a previously assumed zero with a small number close to zero. However, there were issues with deriving the new value: lack of clear information as to which of the assumptions made were incorrect; more than likely lack of an exact unique solution being possible due to there being too many unknowns; and with too many possibilities. A heuristic search of possible values for the previously zero cell had to be performed, with a sensible measure of what constituted the best fit to the system of equations.

The search strategy employed was as follows:

(1) In order to decide which zero cells to change, we identified the equations that fed into the calculation of the invalid probabilities (i.e. negative or >1), and focussed on changing the terms which were previously set to zero in those equations.

(2) We started with the equation that was the earliest in the cascade of equations, and then moved to the next and so on. In this way we were ruling out earlier assumptions in the cascade, before moving on to checking the later assumptions.

(3) We could tell via algebra what the minimum value should be for the sum of the non-zero cells in an equation in order to give a valid probability for a problematic cell. So the search started at combinations of the previously non-zero cells that added to this value.

(4) It was decided to keep the search as simple as possible by trying to adjust one 'previously-zero' term in the equation at a time, and then combinations of two, and so on.

(5) We searched by increasing each value by small increments (+0.01), and recording each search's measure of 'fit' (see below). We considered that our assumptions (i.e. steady progression, and one step at a time), were probably mostly correct, so we focussed our searching in small incremental changes close to the initial zero value assumed.

The measure of 'fit' employed was as follows:

(1) We compared each of the four 'row equation' results with their corresponding 'column equation' result, i.e. for each of $P[D_{mild(a+1)}|D_{none(a)}]$, $P[D_{moderate(a+1)}|D_{mild(a)}]$, $P[D_{severe(a+1)}|D_{moderate(a)}]$, and $P[_{Dsevere(a+1)}|D_{severe(a)}]$. There are two equations that can derive their value – one from the rows of the matrix, and the other from the columns. The thinking was that if our adjustment to the 'previously-zero' cells was a good fit to the system of equations, then the result of the row equation should be exactly the same as or extremely close to the result for the column equation. In order to assess this, we took the absolute value of the difference between the row equation result and the column equation result for each pair of equations, and then summed the four absolute values. This was our measure of 'fit' for each attempt we made at adjusting our assumptions by changing the 'previously-zero' cells – we termed this the 'error'.

(2) We picked the new value for the 'previously-zero' cell(s) that gave the smallest absolute error, and if there was a tie, the term that was closest to zero (i.e. as close to our original assumption as possible).

(3) We recalculated all the probabilities in the cascade of equations using the new value(s) for the 'previously-zero' cells that we decided to change, and made sure that all resulting probabilities were between 0 and 1.

(4) If all probabilities were between 0 and 1, we undertook verification by running a simulation on the original NZDS 1996 survey data using the newly calculated transition probabilities – if the resulting prediction of the disability level distribution for 2001 looked similar to the actual 2001 NZDS data, then we stopped our search (Tables 2 and 3).

Table 2 Verification of disability level transition probabilities (for householders)

1996			2001			
Age Group	Gender	Disability level	Actual		Simulated	
			weighted n	weighted %	weighted n	weighted %
1	1	1	29600	53.6	22244	48.6
1	1	2	9000	16.3	8702	19.0
1	1	3	11900	21.5	9645	21.1
1	1	4	4770	8.6	5149	11.3
1	2	1	29600	49.9	29931	50.0
1	2	2	11600	19.6	10880	18.2
1	2	3	12900	21.8	13807	23.1
1	2	4	5200	8.7	5203	8.7
2	1	1	20200	48.2	19196	50.5
2	1	2	5900	14.0	4457	11.7
2	1	3	11700	28.0	10309	27.1
2	1	4	4100	9.9	4057	10.7
2	2	1	22200	43.8	25746	45.1
2	2	2	9200	18.2	10071	17.6
2	2	3	14900	29.5	16967	29.7
2	2	4	4300	8.5	4314	7.6
3	1	1	6900	32.0	7359	34.1
3	1	2	2800	12.9	2329	10.8
3	1	3	8000	37.5	8997	41.7
3	1	4	3800	17.5	2914	13.5
3	2	1	12800	31.0	12447	32.6
3	2	2	4300	10.4	3948	10.3
3	2	3	18200	44.0	17167	45.0
3	2	4	6000	14.6	4630	12.1
4	1	1	Confidential	Confidential	1343	11.9
4	1	2	Confidential	Confidential	1381	12.2
4	1	3	Confidential	Confidential	4320	38.1
4	1	4	Confidential	Confidential	4283	37.8
4	2	1	2600	13.5	2299	10.8
4	2	2	1700	8.5	2050	9.6
4	2	3	9800	50.0	12491	58.7
4	2	4	5500	28.1	4436	20.9
5	1	1				
5	1	2				
5	1	3	1480	55.0	1953	54.3
5	1	4	1200	45.1	1642	45.7
5	2	1	Confidential	Confidential	533	5.7
5	2	2	Confidential	Confidential		
5	2	3	Confidential	Confidential	3472	36.8
5	2	4	Confidential	Confidential	5423	57.5

Age group: 1 = '65-69', 2 = '70-74', 3 = '75-79', 4 = '80-84', 5 = '85+'

Gender: 1 = 'female', 2 = 'male'

Disability level: 1 = 'none', 2 = 'mild', 3 = 'moderate', 4 = 'severe'

Table 3 Verification of disability level transition probabilities (for residents)

1996		2001			
Age Group	Disability Level	Actual		Simulated	
		weighted n	weighted %	weighted n	weighted %
1	1				
1	2	Confidential			
1	3			362	62.9
1	4			213	37.1
2	1				
2	2				
2	3				
2	4			821	100.0
3	1				
3	2				
3	3			193	20.7
3	4			741	79.4
4	1				
4	2				
4	3			375	31.1
4	4			833	68.9
5	1				
5	2				
5	3			254	11.3
5	4			1994	88.7

Note: 2001 actual data cannot be presented for confidentiality reasons – but were similar to simulated results shown.
Age group: 1 = '65-69', 2 = '70-74', 3 = '75-79', 4 = '80-84', 5 = '85+'
Disability level: 1 = 'none', 2 = 'mild', 3 = 'moderate', 4 = 'severe'

In this way we obtained transition probabilities for disability state for householders using age group, gender, and current disability status as predictors; and similarly for residents though here the only predictors were age group and current disability status, as there were insufficient numbers to enable gender as a predictor (see Appendix, Tables A9 and A10 respectively).

3.4.3.2 Transition probabilities: Long-term illness; residential-care; partnership

A similar methodology was applied in order to obtain transition probabilities for other time-variant states. *Long-term illness* – the other main state together with *disability level* - was predicted using age group, gender, and current long term illness status. *Residential-care status* was predicted using age group, gender, and current residential-care status. *Partnership status* was predicted using age group, gender, and current partnership status. Note that the NZHS 1996 survey did not have long-term illness data so we had to use NZHS

2002 and 2006 to derive long-term illness transition probabilities (whereas for the other states we were able to use 1996 and 2001 data).

We assumed that the presence or absence of *long-term illness*, reflecting need, was the prime driver of health care use. Therefore long-term illness was first estimated dynamically with the results then flowing through to subsequent models of health service use (Figure 1). For long-term illness, a matrix of probabilities could be set up, given the starting 2001 and ending 2006 proportions and following the ‘one-way’ and ‘one-step-at-a-time’ rules (Figure 6). Thus certain cells could be assigned probability values of ‘0’ and ‘1’ and a searching algorithm employed to solve the remaining cell entries.

Figure 6 Long-term illness – matrix and equations

2006 Transition probabilities 2001

$$\begin{bmatrix} P[NLT_{(a+1)}] \\ P[LT_{(a+1)}] \end{bmatrix} = \begin{bmatrix} P[NLT_{(a+1)} | LT_{(a)}] & 0 \\ P[LT_{(a+1)} | NLT_{(a)}] & 1 \end{bmatrix} * \begin{bmatrix} P[NLT_{(a)}] \\ P[LT_{(a)}] \end{bmatrix}$$

```
pwasLT=sum0203_longtermyes/(sum0203_longtermyes+sum0203_longtermno);
pwasNLT=sum0203_longtermno/(sum0203_longtermyes+sum0203_longtermno);
pLTnow=sum0607_longtermyes/(sum0607_longtermyes+sum0607_longtermno);
pNLTnow=sum0607_longtermno/(sum0607_longtermyes+sum0607_longtermno);

pNLTgivenNLT=pNLTnow/PwasNLT;
pLTgivenNLT=1-pNLTgivenNLT;
```

Below gives the formula – showing the assumptions of 0 and 1 – used to derive the transition probabilities for each age-gender subgroup:

$$\begin{matrix} P[V_{N(a+1)}] \\ P[V_{Y(a+1)}] \end{matrix} = \begin{matrix} P[V_{N(a+1)} | V_{N(a)}] & 0 \\ P[V_{Y(a+1)} | V_{N(a)}] & 1 \end{matrix} * \begin{bmatrix} P[V_{N(a)}] \\ P[V_{Y(a)}] \end{bmatrix}$$

Resultant transition probabilities for long-term illness (and residential-care status and partnership) are provided in the Appendix, Tables A11, A12, and A13 respectively.

Verification of these factors was carried out by applying the derived transition probabilities to the simulation and comparing the results to actual outcomes in the original data (long-term illness: Table 4; residential-care status (Appendix, Table A14); and partnership status (Appendix, Table A15).

Table 4 Verification of long-term illness transition probabilities

2001		2006	
Age Group	**Gender**	**Actual (% with long-term illness)**	**Simulated (% with long-term illness)**
1	Female	89.9	89.1
1	Male	89.5	88.7
2	Female	92.1	90.6
2	Male	86.8	90.3
3	Female	93.5	95.1
3	Male	94.6	95.3
4	Female	91.2	89.9
4	Male	90.2	94.2
5	Female	86.4	87.7
5	Male	90.9	100.0

Age group: 1 = ’65-69’, 2 = ’70-74’, 3 = ’75-79’, 4 = ’80-84’, 5 = ‘85+’

3.4.3.3 Transition probabilities: Death

Transition probabilities for death over each 5-year period were derived using the following procedure:

(1) We obtained life tables giving the probability by gender and ethnicity (non-Māori , Māori, and Pacific) of a person who has reached a certain age living another year *(Statistics NZ, http://www.stats.govt.nz/browse_for_stats/health/life _expectancy.aspx)*.

(2) The probability of still being alive in another 5 years for each age was calculated by multiplying together the needed 5 probabilities of still being alive in another year, for a given gender and ethnicity combination, i.e. multiplying the probability of staying alive for the age of interest, by the corresponding probabilities for ‘age +1’, ‘age +2’, ‘age+3’, and ‘age+4’. In so doing, we multiply - for a given ethnicity, gender, and age - the probability of living another year (when they would be aged ‘age +1’ if they survived) by the probability for such a person - if they did reach ‘age+1’ - still being alive by ‘age +2’, and so on up until the chance of their reaching ‘age+4’ . As ‘age +4’ is 5 years from their original age, this multiplication product then gives the probability of a person still being alive 5 years into the future ‘PAlive5yrs’.

(3) The life tables only gave probabilities of being alive in a year’s time for people up to 100 years of age. This meant that, using the raw data, probabilities of being alive 5 years hence could only be calculated for those 96 years of age or younger. For example, to get the 5-year probability for a 97 year-old, we would need the one-year probabilities for all of the following ages - 97, 98, 99, 100, and 101 – and we would not have a value for a 101 year old. This was a problem as we needed to have mortality probabilities at the ready for a whole range of possibly simulated future

ages, the maximum value of which is unknown in advance. The base file (starting sample) contained people aged up to 99 years, and even if a person was under 97 in the base file, they could potentially age above this value as the simulation unfolded. It was therefore decided to impute the probability of being alive in one year's time, for ages above 96. First of all we calculated the differences in the rate of change of probability from one year to the next for all the relevant years where there were life table data, i.e. for ages 65 to 100. We then applied this rate of change to ages above 100, which, together with the probability value for the previous age, was used to impute the probability for ages above 100. An added complication was the need to adjust death transition probabilities by disability level for which there were only data for people up to 99 years of age (see step (5) below). It was therefore decided to only impute the probability of being alive in one year to the ages (above 100) 101 to 103, which gave sufficient information to produce a probability of being alive in 5 years' time for people aged 97-99 years. For people aged over 99 years, we assigned their mortality probability to be that of a 99 year old.

(4) For each age, gender, and ethnicity cell, we calculated the hazard (h) of death, i.e. the chance of death happening between 5 years after the age in question and an infinitesimal amount of time later, where that amount tends to zero. We know that the survival function (i.e. the probability that the death event will not happen until after time t) is S(t)=exp(-h*t), and that S(t)=PAlive5yrs which rearranges to h(t)=ln(PAlive5yrs)/5.

(5) These h(5) hazards were then adjusted by disability level - 'none', 'light', 'moderate', 'severe (but not living in an institution)', and 'living in an institution' - for each gender and age combination, using specific relative risks of mortality *(Statistics Canada 2008)*. The adjustment was carried out by multiplying the hazard for death by the specific relative risk. This then gave, for each age and gender combination, a set of 5 disability-adjusted hazards of death – h(5)– one for each of the disability levels.

(6) These adjusted hazards of death were then converted to S(5) which are 5-year adjusted survival probabilities using the formula S(5)=exp(-h*5).

(7) Finally S(5) was converted into a 5-year adjusted death probability, i.e. the probability of dying in the next 5 years is equal to 1-S(5), i.e. 1 minus the probability of still being alive in 5 years (results are shown in Appendix, Tables A16-A27).

4. Simulation

The starting sample for simulation comprised original data on older people in the base year 2001. The simulation process for each subsequent time interval followed a sequence of steps from demographic characteristics, through health or disability status, to final health care or social care outcomes. Older people living in the community and in residential care facilities were considered separately because of the structure of the data.

We generated a virtual cohort from a starting sample of 2,807 older people representing the 65+ population in New Zealand for the period 2001 to 2021. Survey weights were split and used to clone cases to increase the starting sample size (to 8715, each with weight of 50) for simulation. We then applied equations (derived from analysis of the national survey data) to update time-variant attributes at 5-year intervals using a stochastic Monte Carlo process. Thus we were able to age the cohort.

To maintain representativeness of the sample as the cohort aged over time, we made demographic adjustments as follows:

- Risks of mortality were derived from life tables *(Statistics NZ, http://www.stats.govt.nz/browse_for_stats/health/life_expectancy.aspx)*, adjusted by disability *(Statistics Canada 2008)*, and applied to gender-age groups.

- The sample was rejuvenated with new entrants in proportion to population censuses and official projections. At each subsequent 5-yearly interval, a random draw of 65-69 year-olds replaced those individuals who had progressed to the 70-74 years age group.

- Re-weighting was employed to account for migration and for future demographic trends according to official projections based on medium fertility, mortality, and migration.

To reduce the effect of random error, a simulated estimate was taken as the average result of 20 runs. This was sufficient to generate a stable estimate with a tight 95 per cent confidence interval. Thus a sample of typical though varied individual life histories was created. Further adjustments were applied to calibrate for reproducibility of benchmarks and population-level representativeness. The final simulated virtual cohort was designed to approximate patterns found in the real data.

4.1 Simulation process

The base file in the simulation used 2,807 real-life records made up of 2206 people living in households, and 601 people living in residential care. These records were then cloned to produce 8715 records made up of 7926 records of householders, and 789 records of residents (see Section 4.6 Cloning). These were the records from 2001 that were simulated forward in the first iteration of the simulation, leading to simulated values for 2006.

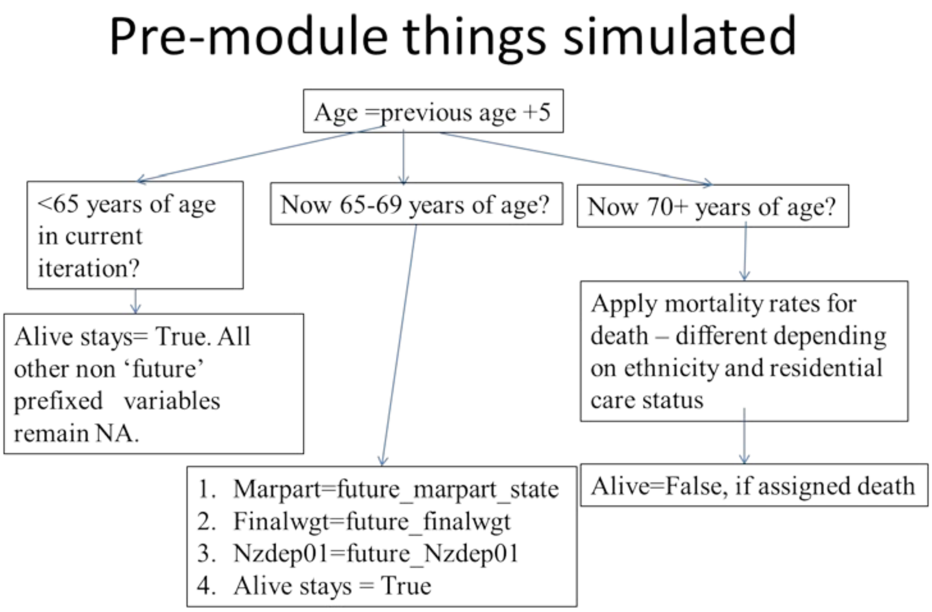
There were two modules – the health care module and the social care module. At the start, people who were in residential care, or who were simulated as being in residential care, did not continue onwards to the health care module. Every record was input to the social care module regardless of residential-care status.

We simulated the 65+ year-old population at 5-year intervals, starting with 2006, 5 years on from our base file which was labelled as 2001 (though actually made up of NZDS 2001/2002 for residents and NZHS 2002/03 for householders). We were therefore simulating years 2006, 2011, 2016, and 2021. At each iteration or year, we needed to replenish the 65-69 year old group - this was done in advance by having four copies (one for each year) of 65-69 year-olds in the NZDS 2001/2 and the NZHS 2002/3 added to the base file, and 'waiting in the wings'. Each copy was given their original age (65-69 years) minus the number of years before they would enter that age group for the iteration year in question. These records were aged forward 5 years at each iteration until they entered the 65-69 year-old bracket when they would become part of the simulation (they 'came of age'). These 'newbies' (new entrants) were weighted to be representative of 65-69 year-olds in the iteration year. When creating the base file (before the simulation), each 'newbie' record's variables were copied (apart from 'age') and prefixed 'future_', and the original versions made empty. Then in the simulation the 'newbies' would be ignored (as their empty variables do not contribute to the output tables) until such time as they 'come of age' when the simulation makes their values equal to the 'future_' prefixed versions.

The following flow diagrams (Figures 7 to 11) show what the simulation does both at the beginning of the simulation (pre-module), and for the two different modules (note that different things are done depending on whether a record is a 'newbie' or not).

4.2 Pre-module

Figure 7 Pre-module process



4.3 Health care module

Figure 8 Health care module ('non-newbies') process

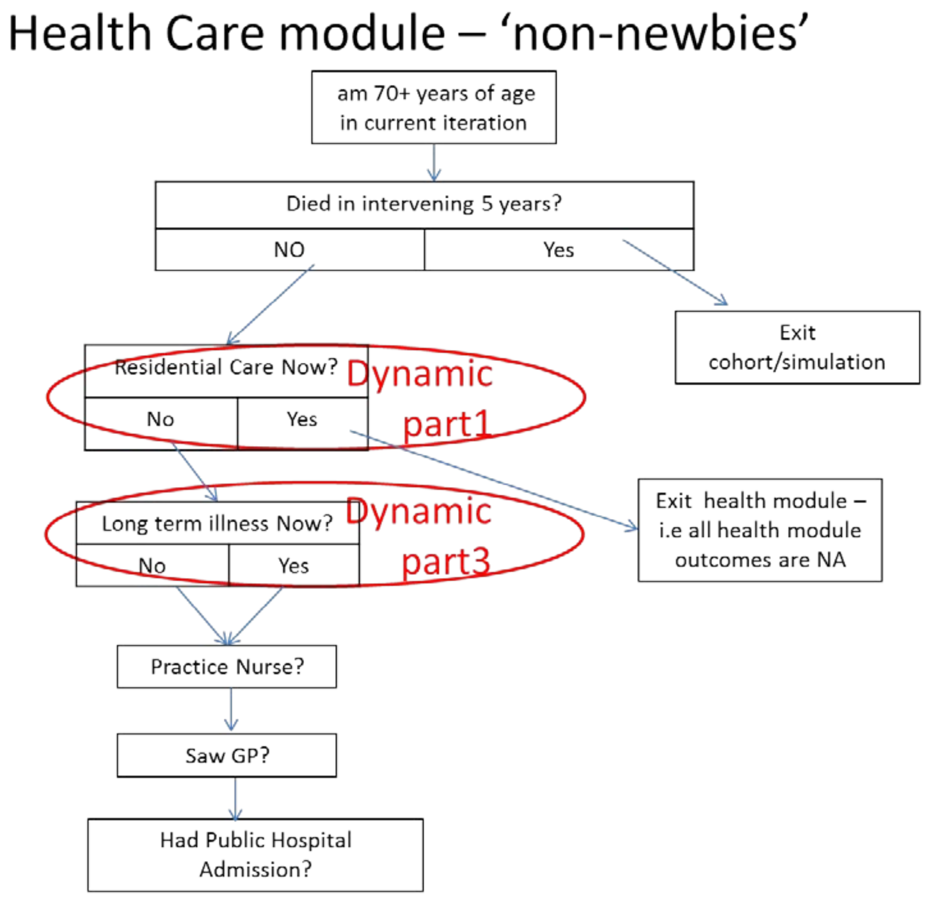
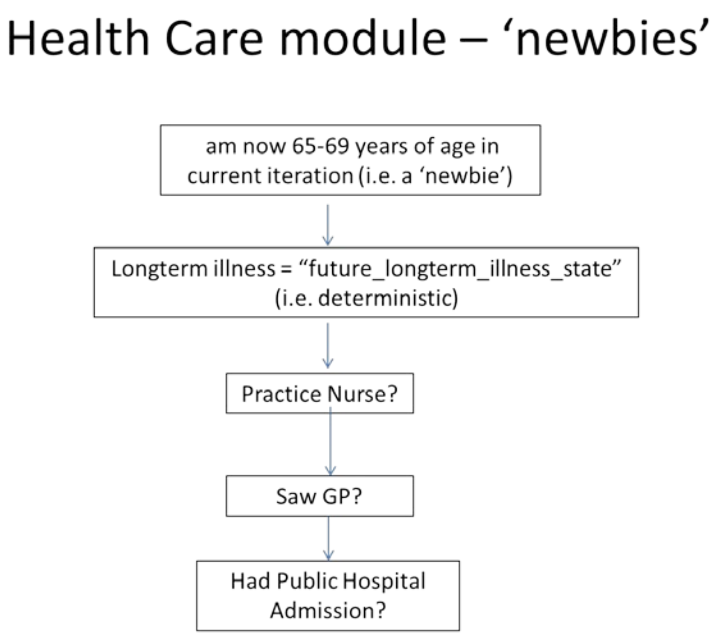


Figure 9 Health care module ('newbies') process



4.4 Social care module

Figure 10 Social care module ('non-newbies') process

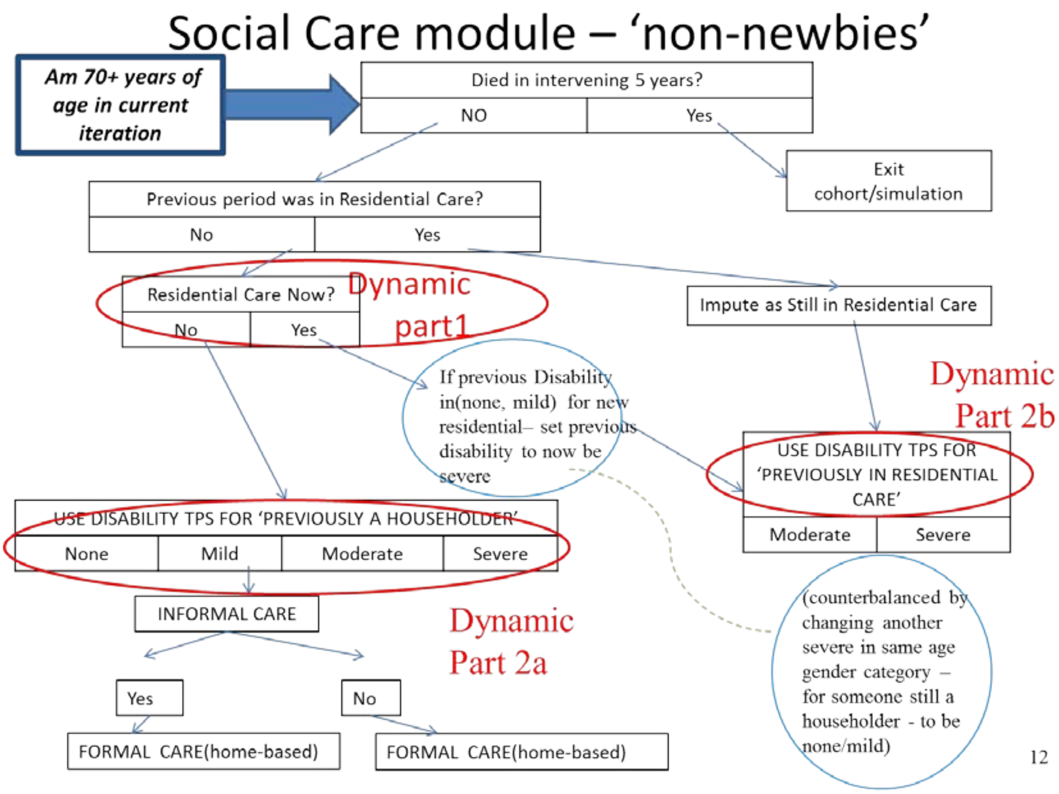
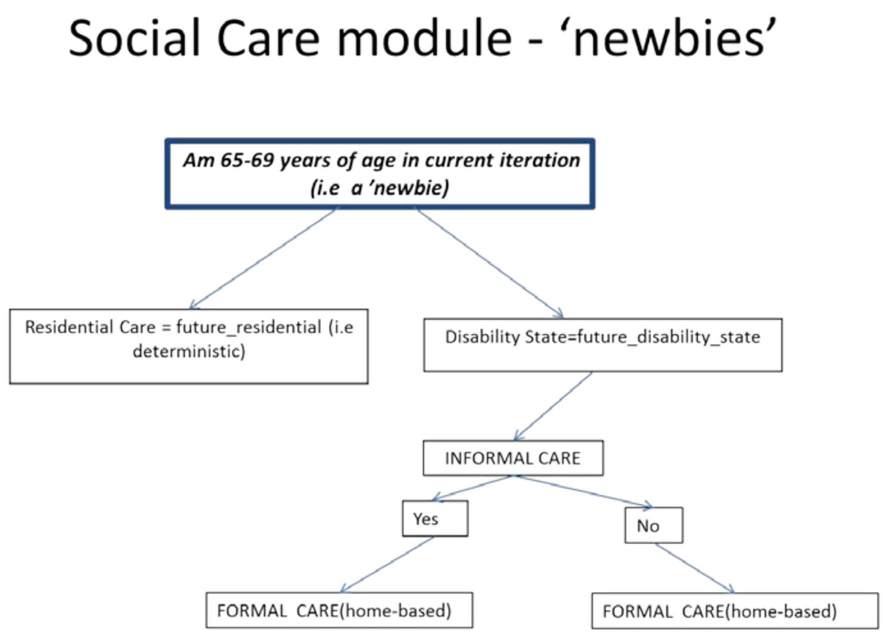


Figure 11 Social care module ('newbies') process



As all records regardless of residential-care status entered the social care module, but were nevertheless simulated differently depending on this status, below are presented flow digrams indicating how informal and formal care were simulated (Figures 12 to 14). Note that deterministic decisions shown were based on assessment of the actual data.

Figure 12 Informal care process

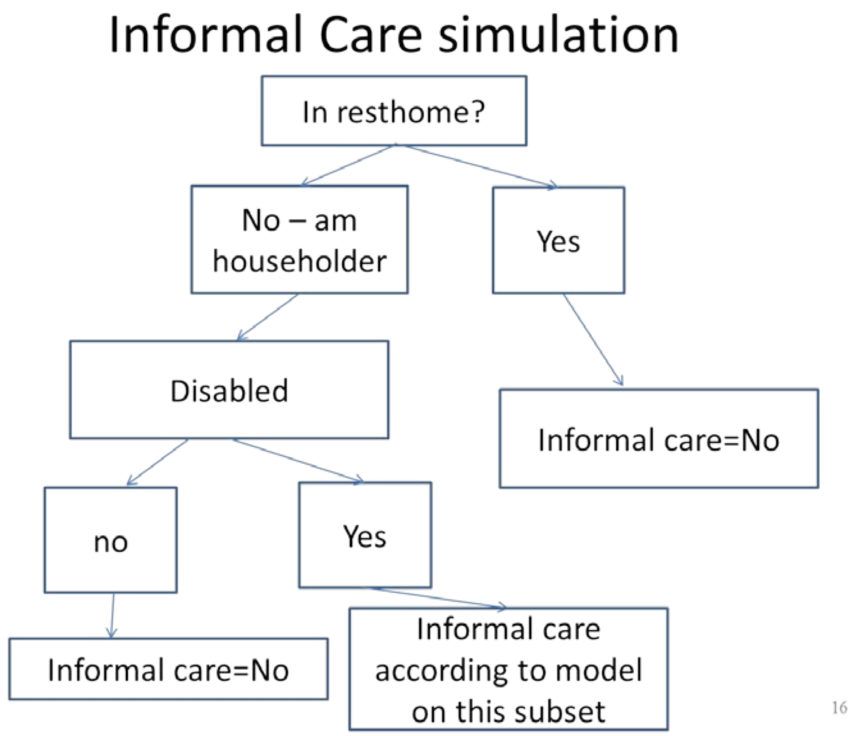


Figure 13 Formal care process

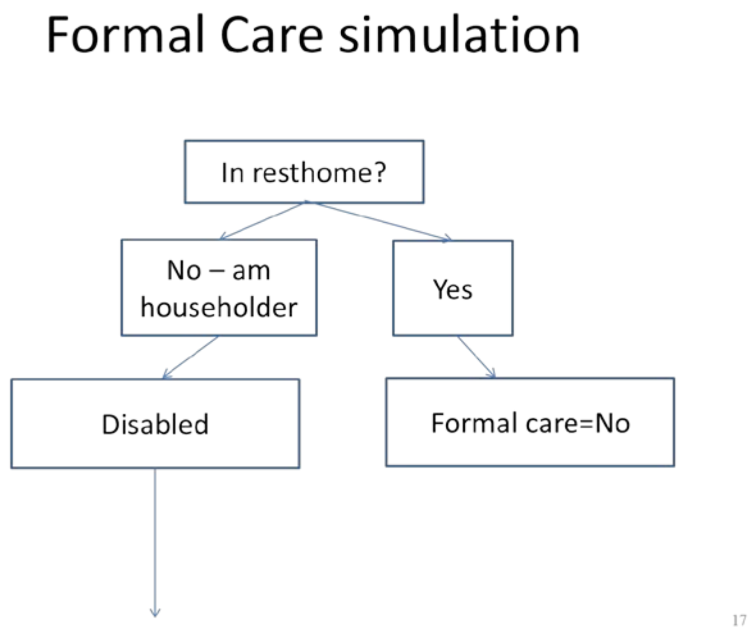
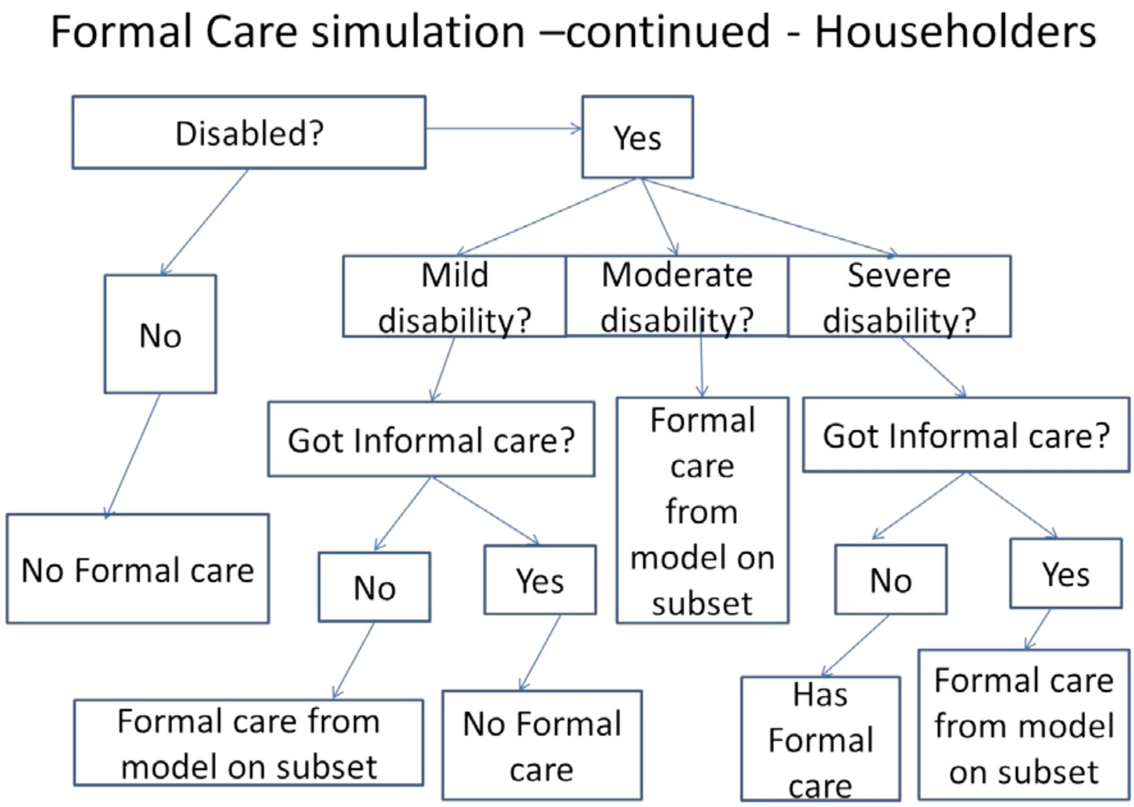


Figure 14 Formal care (householders) process



4.5 Propensities to change state

Some forms of scenario testing involve changing the prevalence of a characteristic (e.g. long-term illness) or the distribution of a characteristic (e.g. disability level) either at baseline or at any iteration (i.e. year/period) of the simulation. In order to do this, some records have to necessarily change from being in one category (e.g. not having long-term illness) to being in another category (e.g. to having long-term illness). The propensity gives the chance of a record which is in a particular category for a variable, moving from that category up to the next highest category, as a result of the mechanism envisaged to be happening when a scenario is undertaken. For example, the scenario 'decreasing long-term illness' in the simulation at baseline, is operationalizing a mechanism whereby people who originally had long term illness do not now have long term illness in this alternative world (perhaps as the result of some type of policy intervention). In this case the propensity is the chance of each record being the kind of person that would move from having no long-term illness to having long-term illness had they just experienced different life circumstances.

In the absence of such information, we used proxies. For those time-variant predictor variables, such as long-term illness, we used the proxy of our calculated transition probabilities (see above) which provide, for example, the chance of a person with their given set of characteristics (their previous age, gender, residential-care status and long-term illness category) having long-term illness within the next 5 years. For time-variant outcome variables, such as informal care, we used probabilities based on deterministic assumptions or from statistical models, e.g. those without disability were automatically given zero probability of informal care in the simulation while those disabled were given probability of informal care based on a statistical model. For multiple category variables, such as GP visit level, we required the probability of moving from category 1 to category 2, and from category 2 to category 3, and so on, but as a proxy we used the probability of being in each destination category derived from a multinomial model.

Ultimately these propensities were compared and ranked among all individuals in the data set to give rank scores that would identify those most likely to move from one category to the next category of a variable of interest. In implementing a scenario where a baseline characteristic needed to be altered, we would select those records with the highest rank scores to be moved.

4.6 Cloning

Cloning of each record - based on their survey weight which varied among records - was undertaken to enable each record to be worth – as much as possible - the same amount. This was important for two reasons:

- To ensure that scenario proportions were output with prior adjustment for the correct weighting of each record.
- To enable better representation of the true variation in a particular covariate pattern (e.g. age 70, male, etc.). If the original un-cloned record had, for example, a weight of 500, then ideally taking 500 draws from the distribution for this covariate pattern (rather than one draw only) would ensure that the full range of variable values was represented in the simulation *(Abello et al. 2008)*.

The ideal would have been to clone the records so that each unit of weight was represented by one record, e.g. an un-cloned record having a weight of 500 would be cloned to 500 records each with a weight of 1. However, such a large data set would have been problematic given software and computing limitations. We found that a common record weight of 50 resulted in the number of clones that could be handled by our software, and seemed reasonable given the population size under study. With each record representing close to 50 people, this was a smaller proportion of the population than originally.

The cloning process itself was different depending on the original weight of the record:

- Records where the original weight was less than 50 were not cloned.

- Records where the original weight was divisible by 50 (e.g. a weight of 400) were cloned according to the number of records given by the quantity ‘original weight/50’, e.g.. 400/50 = 8 cloned records.

- Records where the original weight was greater than 50, but not divisible by 50 (e.g. a weight of 420) were cloned in two parts. The first part consisted of cloning to represent the part of the original weight that was able to be divided by 50 (e.g. 8 clones each with weight 50, representing 400 of the original weight). The second part consisted of dealing with the remainder of the original weight (e.g. 420 – 400 = 20). This was usually done by distributing the remainder across the previously created clones for the divisible part (e.g. 20 is distributed across 8 clones, resulting in those clones then having an extra weight of 20/8 = 2.5 added to 50). The result is that, in this example, an original record with a weight of 420 would be cloned to 8 records each with a weight of 52.5. We set a limit of 10 for the amount of extra weight that could be added to 50 for a record. If the remainder exceeded this limit, it was placed in a new clone of its own, rather than being distributed across the already existing clones. This meant that the maximum weight for any record was restricted to 50+10 = 60.

5. Validation

Validation of simulated results was carried out by comparison to the actual real-world NZHS and NZDS data (2006). The test was whether the simulation model was able to reproduce averages and a similar distribution of outcomes as occurred in the benchmark data. Where necessary and possible, simulated quantities were calibrated (before or during simulation) or aligned (after simulation) to external benchmarks so that findings could be generalised to the New Zealand population. It must be noted that this was an iterative process in which any discrepancies were addressed by returning to and improving the model.

5.1 Validation: hierarchical process

A hierarchical approach was undertaken when validating the simulation model in order to streamline the validation process.

Validation was split into two parts:

- *Primary validation* consisted of checking that numbers were correct by basic socio-demographic variables of age, gender, and ethnicity, according to actual or projected information *(Statistics NZ, http://www.stats.govt.nz/browse_for_stats/population.aspx)*. Age and gender, in particular, were common predictors of downstream outcomes. The number in each age-gender-ethnicity cell in each year of the simulation, and the benchmark population for that cell was compared. Calibration was undertaken where there were discrepancies.

- *Secondary validation* consisted of checking that the proportions in the downstream variables were correct by primary socio-demographic - and other - variables (against actual 2006 survey data).

Secondary validation was undertaken in sequential order, with variables at the top of the simulation process validated first – residential care status then disability level, long-term illness, and partnership. Subsequently, module-specific variables were validated, again in order within each module: health care – firstly practice nurse visit, then GP visit, then public hospital admission; and social care – informal care, followed by formal care.

This enabled any problems with validation at the top of the simulation process to be eliminated first before assessing if there were further problems down the line. As a generic approach, calibrations were carried out for proportions if they were greater than 10 percentage points off beam. Calibration of a variable according to by-groups was only carried out if those by-group variables were predictors of the variable in question.

5.2 Primary validation

The original simulated population numbers in 2006 by age group and gender did not validate well against the 2006 Census benchmark (Table 5).

Table 5 Un-calibrated simulated versus actual population numbers in 2006 by age group and gender

	NZ Projected Population 2006 (Statistics NZ)			Simulation 2006		
Age Group (years)	Male	Female	Total	Male	Female	Total
65–69	75,620	79,910	155,530	71,903	76,324	148,227
70–74	57,380	62,790	120,170	48,440	57,589	106,029
75–79	47,570	56,030	103,600	33,135	48,076	81,211
80–84	30,180	44,000	74,180	30,793	35,635	66,428
85 and over	18,180	39,960	58,140	18,879	38,276	57,155
Total	228,930	282,690	511,620	203,150	255,900	459,050

The suspected reasons were as follows:

(1) The part of the base file from NZDS came from the year 2001/2002 while the part from NZHS came from the year 2002/03; these were the only data available for our purposes. Though we were aiming to represent 2001, and comparing to the official 2001 projection.

(2) Migration was not explicitly taken into account as relevant data were unavailable.

(3) We used Canadian relative risks (RRs) of death by disability level (and age and gender) as NZ-specific information was unavailable *(Statistics Canada 2008)*. Differences in these RRs by ethnicity (particularly between Māori and non-Māori) were not accounted for, though NZ life tables report information by ethnicity. The distribution of disability level by age and gender in NZ and Canada *(Statistics Canada 2002)* was also comparable (Appendix, Table A28).

In the absence of further available information, we calibrated the simulated population numbers directly to the benchmark. The benchmark data used were, where possible, either preferably projected population numbers *(Statistics NZ, http://www.stats.govt.nz/browse_for_stats/population.aspx)* or actual population numbers from the NZ Census, broken down by age, gender and prioritised ethnicity.

The calibration procedure, implemented in the simulation process itself, was as follows:

(1) Within the simulation run for 2006, calculate the difference between the benchmark population number for a cell (age*gender*ethnicity), and the simulated number. Divide this difference by the weighted sum of weights for that cell to obtain the 2006 calibration factor for that cell.

(2) Run the 2011 simulation with 2006 calibration factors applied to cells. The simulated result is the population number in each cell.

(3) Calculate the 2011 calibration factor for each cell (age*gender*ethnicity) as:

[(result from step 2) – (2011 benchmark)]/(2011 benchmark).

(4) Repeat steps 2 and 3 for the 2016 simulation.

(5) Repeat steps 2 and 3 for the 2021 simulation.

Following this 'real-time' calibration, simulated population numbers in 2006 by age group, gender, and ethnicity compared favourably against the 2006 Census benchmark (Tables 6 and 7). Simulated Māori and non-Māori population numbers by age group and gender in 2011, 2016, and 2021 were also compared against official projections (Appendix, Tables A29-A32).

Table 6 Calibrated simulated versus actual population numbers in 2006 by age group, and ethnicity: Males

Ethnicity	**Age Group (years)**				
	65-69	**70-74**	**75-79**	**80-84**	**85+**
	NZ Census 2006 (Simulation 2006)				
Māori	5022 (5023)	3158 (3159)	1675 (1675)	719 (720)	285 (286)
Pacific	2059 (2059)	1185 (1185)	742 (742)	334 (334)	135 (95)*
Asian	3410 (3410)	2295 (2295)	1163 (1164)	541 (542)	282 (283)
Middle-Eastern/Latin-American/African	159 (160)	130 (79)*	93 (94)	46 (47)	21 (18)
European/Other (mostly 'New Zealander')	61423 (61424)	49077 (49078)	42656 (42657)	27480 (27481)	16932 (16932)

*small numbers in the sample

Table 7 Calibrated simulated versus actual population numbers in 2006 by age group, and ethnicity: Females

Ethnicity	Age Group (years)				
	65-69	70-74	75-79	80-84	85+
	NZ Census 2006 (Simulation 2006)				
Māori	5518 (5518)	3599 (3599)	2272 (2272)	1109 (1109)	625 (625)
Pacific	2338 (2338)	1591 (1591)	1019 (1019)	573 (573)	342 (342)
Asian	3688 (3688)	2391 (2391)	1315 (1315)	742 (742)	498 9498)
Middle-Eastern/Latin-American/African	209 (208)	146 (146)	84 (84)	59 (53)	34 (34)
European/Other (mostly 'New Zealander')	64672 (64672)	53326 (53326)	50167 (50167)	40624 (40624)	37480 (37480)

5.3 Secondary validation

5.3.1 Disability state

Simulated proportions of residential-care status and disability state validated well against 2006 benchmarks. However, there were discrepancies in householders' disability state by age group (Table 8).

Table 8 Disability level by age group (for householders): Un-calibrated simulated results compared to actual data, 2006

Disability Level	Age Group (years)				
	65-69	70-74	75-79	80-84	85+
	NZ Disability Survey 2006 (%)				
None	71.5	62.4	58.1	42.8	29.6
Mild	11.8	14.0	12.4	10.0	7.7
Moderate	13.1	19.0	23.9	35.6	44.6
Severe	3.6	4.6	5.6	11.7	18.2
	Simulation 2006 (%)				
None	59.3	47.2	43.9	36.6	9.6
Mild	17.3	17.6	17.6	8.2	4.8
Moderate	18.2	24.4	29.3	40.1	45.7
Severe	5.2	10.8	9.2	15.0	39.9

Bearing in mind that there may have been inconsistencies in the measurement of disability level between the NZDS 2001 and 2006 *(Statistics NZ 2009, 2013)* – particularly impacting on the 'none' category which could be discrepant by up to 10 percentage points – the only age group that stood out as comparing poorly was the 85+ group. We examined NZDS 1996 and 2001 data to see how constant the proportions for this age group (85+) were over time (Table 9).

Table 9 Comparison of disability level for 85 years and over age group between 1996 and 2001

Disability Level	NZ Disability Survey	
	1996 (%)	2001 (%)
None	18.8	12.7
Mild	7.53	8.3
Moderate	50.3	54.1
Severe	23.3	24.9

Given that the disability proportions in this age group looked similar in 1996 and 2001, we surmised that they would remain stable over time. We calibrated our 2006 simulated results to the 2001 NZDS data (Table 10).

Table 10 Disability level for 85 years and over age group (householders): calibrated simulated results compared to actual data

Disability Level	Simulation 2006 (%)	NZ Disability Survey 2001 (%)	Required calibration	
			% increase	% decrease
None	9.6	12.7	32.2	-
Mild	4.8	8.3	74.2	-
Moderate	45.7	54.1	18.4	-
Severe	39.9	24.9	-	37.7

These percentage increases/decreases were applied to the 85+ group every year (iteration) of the simulation, and once calculated the increased/decreased proportions were weighted to sum to 1, to ensure that they gave a proper probability distribution.

5.3.2 Disability state - calibrated

Tables 11 to 16 compare proportions in the various disability levels – overall, and by age group and gender – for householders and residents respectively between the calibrated

2006 simulation and the benchmark NZDS 2006 data. The results show the simulation was matching more closely to the actual data.

Table 11 Disability level (for householders): Calibrated simulated results compared to actual data, 2006

Disability Level	NZ Disability Survey 2006 (%)	Simulation 2006 (%)
None	58.9	45.9
Mild	11.9	15.2
Moderate	22.6	28.3
Severe	6.6	10.6

Table 12 Disability level by age group (for householders): Calibrated simulated results compared to actual data, 2006

Disability Level	Age Group				
	65-69	**70-74**	**75-79**	**80-84**	**85+**
			NZ Disability Survey 2006 (%)		
None	71.5	62.4	58.1	42.8	29.6
Mild	11.8	14.0	12.4	10.0	7.7
Moderate	13.1	19.0	23.9	35.6	44.6
Severe	3.6	4.6	5.6	11.7	18.2
			Simulation 2006 *(%)*		
None	59.3	47.3	44.3	36.6	12.8
Mild	17.3	17.3	17.5	8.2	8.0
Moderate	18.2	24.7	29.4	39.7	53.7
Severe	5.2	10.7	8.7	15.6	25.6

Table 13 Disability level by gender (for householders): Calibrated simulated results compared to actual data, 2006

Gender	Disability Level			
	None	**Mild**	**Moderate**	**Severe**
		NZ Disability Survey 2006 (%)		
Male	58.8	13.5	20.2	07.5
Female	59.0	10.5	24.7	05.8
		Simulation 2006 (%)		
Male	51.1	15.3	23.0	10.7
Female	41.5	15.2	32.8	10.5

Table 14 Disability level (for residents): Calibrated simulated results compared to actual data, 2006

Disability Level	NZ Disability Survey 2006 (%)	Simulation 2006 (%)
None	Negligibly small numbers here	
Mild		
Moderate	17.0	23.8
Severe	83.0	76.2

Table 15 Disability level by age group (for residents): Calibrated simulated results compared to actual data, 2006

Disability Level	65-69	70-74	75-79	80-84	85+
	NZ Disability Survey 2006 (%)				
None	a	a	a	a	a
Mild	a	a	a	a	a
Moderate	b	b	b	15.6	16.9
				(1200)	(2400)
Severe	b			84.4	83.1
		(1800)	(3100)	(6500)	(11800)
	Simulation 2006 (%)				
None	a	a	a	a	a
Mild	a	a	a	a	a
Moderate	23.4	54.3	2.5	9.5	29.7
Severe	76.6	45.8	97.5	90.5	70.3

a negligibly small numbers
b not available because of confidentiality

Table 16 Disability level by gender (for residents): Calibrated simulated results compared to actual data, 2006

Gender	Disability Level			
	None	Mild	Moderate	Severe
	NZ Disability Survey 2006 (%)			
Male	**a**	**a**	17.1	82.9
Female	**a**	**a**	17.5	82.5
	Simulation 2006 (%)			
Male	a	a	21.1	78.9
Female	a	a	25.1	74.9

a negligibly small numbers

5.3.3 Long-term illness

Tables 17 to 19 compare proportions with log-term illness – overall, and by age group and gender - between the calibrated 2006 simulation and the benchmark NZDS 2006 data. The results show the simulation was matching well to the actual data.

Table 17 Long-term illness: Calibrated simulated results compared to actual data, 2006

	NZ Health Survey 2006	Simulation 2006
Long-term Illness (%)	89.3	86.6

Table 18 Long-term illness by age group: Calibrated simulated results compared to actual data, 2006

Age Group (years)	Long-term Illness (%)	
	NZ Health Survey 2006	Simulation 2006
65-69	86.7	78.0
70-74	89.7	89.2
75-79	89.6	89.8
80-84	94.0	93.8
85+	89.9	91.1

Table 19 Long-term illness by gender: Calibrated simulated results compared to actual data, 2006

Gender	Long-term illness (%)	
	NZ Health Survey 2006	Simulation 2006
Male	87.6	85.5
Female	90.8	87.5

5.3.4 Residential care

Tables 20 to 22 compare proportions by residential-care status – overall, and by age group and gender - between the calibrated 2006 simulation and the benchmark NZDS 2006 data. The results show the simulation was matching well to the actual data.

Table 20 Percentage in residential care: Simulated results compared to actual data, 2006

	NZ Disability Survey 2006	Simulation 2006
Residential Care (%)	5.9	6.4

Table 21 Percentage in residential care by age group: Simulated results compared to actual data, 2006

Age Group (years)	Residential Care (%)	
	NZ Disability Survey 2006	Simulation 2006
65-69	-	1.3
70-74	4.9	2.8
75-79	8.5	4.7
80-84	17.5	8.6
85+	35.0	27.7

Table 22 Percentage in residential care by gender: Simulated results compared to actual data, 2006

Gender	Residential Care (%)	
	NZ Disability Survey 2006	Simulation 2006
Male	8.8	4.5
Female	16.6	8.0

5.3.5 Partnership

Tables 23 to 25 compare proportions in partnership – overall, and by age group and gender - between the calibrated 2006 simulation and the benchmark NZDS 2006 data. The results show the simulation was matching well to the actual data.

Table 23 Percentage partnered: Simulated results compared to actual data, 2006

	NZ Disability Survey 2006	Simulation 2006
Partnered (%)	61.3	59.4

Table 24 Percentage partnered by age group: Simulated results compared to actual data, 2006

Age Group (years)	Partnership (%)	
	NZ Disability Survey 2006	Simulation 2006
65-69	69.7	72.5
70-74	65.8	73.3
75-79	57.2	55.8
80-84	45.1	39.1
85+	31.4	28.7

Table 25 Percentage partnered by gender: Simulated results compared to actual data, 2006

Gender	Partnership (%)	
	NZ Disability Survey 2006	Simulation 2006
Male	71.6	76.6
Female	34.6	45.5

5.3.6 Practice nurse visit

Practice nurse visit was the first of a sequence of health care outcomes to be simulated. We compared the proportion of individuals who had visited the practice nurse in the last 12 months – overall, and by age group, gender and ethnicity - between the 2006 simulation and actual 2006 NZHS data (Tables 26 to 29).

Table 26 Percentage visited practice nurse: Simulated results (uncalibrated) compared to actual data, 2006

	NZ Health Survey 2006	Simulation 2006 (uncalibrated)
Visited Practice Nurse (on own) (%)	45.5	41.7

Table 27 Percentage visited practice nurse by age group: Simulated results (uncalibrated) compared to actual data, 2006

Age Group (years)	Practice Nurse Visit (%)	
	NZ Health Survey 2006	Simulation 2006 (uncalibrated)
65-74	44.7	43.0
75-84	46.8	43.6
85+	45.2	26.0

Table 28 Percentage visited practice nurse by gender: Simulated results (uncalibrated) compared to actual data, 2006

Gender	Practice Nurse Visit (%)	
	NZ Health Survey 2006	Simulation 2006 (uncalibrated)
Male	43.3	38.9
Female	47.4	44.0

Table 29 Percentage visited practice nurse by ethnic group: Simulated results (uncalibrated) compared to actual data, 2006

Ethnic group	Practice Nurse Visit (%)	
	NZ Health Survey 2006	Simulation 2006 (uncalibrated)
European	46.9	42.5
Māori	45.7	50.6
Pacific	30.4	15.2
Asian	19.7	24.2
Other	16.0	24.5

Simulated results show that ‘practice nurse visit’ was not matching well to the benchmark for the 85+ group (Table 27) and for the third ethnicity group (Pacific) (Table 29). Cross-tabulation of age group and ethnicity for the simulated and benchmark data respectively was undertaken to derive calibration factors (Table 30).

Table 30 Percentage visited practice nurse by ethnic group and age group: Simulated results (uncalibrated) compared to actual data, 2006

Ethnic Group	Age Group	Practice Nurse Visit (%) NZ Health Survey 2006	Simulation 2006 (uncalibrated)	Calibration required (extra amount)
1	1	46.0	44.3	
1	2	48.3	44.2	
1	3	46.4	44.1	
1	4	48.1	44.1	
1	5	45.5	26.3	19.2
2	1	45.9	50.5	
2	2	44.5	51.8	
2	3	47.6	52.1	
2	4	51.3	53.3	
2	5	29.3	28.2	1.1
3	1	24.9	15.0	9.9
3	2	30.9	15.8	15.1
3	3	28.8	16.3	12.5
3	4	49.8	13.9	35.9
3	5	a	10.6	b
4	1	13.2	23.5	
4	2	8.3	23.4	
4	3	34.4	28.9	
4	4	54.0	27.5	
4	5	a	9.7	b
5	1	0	27.9	
5	2	100	19.4	
5	3	a	23.0	
5	4	a	29.2	
5	5	a	0	b

Age group: 1 = '65-69', 2 = '70-74', 3 = '75-79', 4 = '80-84', 5 = '85+'
Ethnic group: 1 = 'European', 2 = 'Māori', 3 = 'Pacific', 4 = 'Asian', 5 = 'Other'
a unavailable for confidentiality reasons; b insufficient information

Each calibration factor represents the additional percentage points in the category 'visited practice nurse' required to meet the benchmark. An absolute increase was deemed more appropriate (than a relative increase) to mitigate over-inflation in the case of already large initial percentages, and in the testing of extreme scenarios. Applying these further calibration factors gave the following simulated results – overall, and by age group, gender and ethnicity - compared to benchmark data (Tables 31 to 34).

Table 31 Percentage visited practice nurse: Simulated results (calibrated) compared to actual data, 2006

	NZ Health Survey 2006	Simulation 2006 (calibrated)
Visited Practice Nurse (on own) (%)	45.5	43.5

Table 32 Percentage visited practice nurse by age group: Simulated results (calibrated) compared to actual data, 2006

Age Group (years)	Practice Nurse Visit (%)	
	NZ Health Survey 2006	**Simulation 2006 (calibrated)**
65-74	44.7	43.0
75-84	46.8	43.9
85+	45.2	44.6

Table 33 Percentage visited practice nurse by gender: Simulated results (calibrated) compared to actual data, 2006

Gender	Practice Nurse Visit (%)	
	NZ Health Survey 2006	**Simulation 2006 (calibrated)**
Male	43.3	40.3
Female	47.4	46.1

Table 34 Percentage visited practice nurse by ethnic group: Simulated results (calibrated) compared to actual data, 2006

Ethnic Group	Practice Nurse Visit (%)	
	NZ Health Survey 2006	**Simulation 2006 (calibrated)**
European	46.9	44.1
Māori	45.7	50.2
Pacific	30.4	29.1
Asian	19.7	25.4
Other	16.0	25.4

After calibration of 'practice nurse visit', simulated results for the 85+ age group and for the Pacific group were comparing well to the benchmark data.

5.3.7 Family doctor (GP) visit

Family doctor visit - after practice nurse visit - was the second outcome in the health care sequence. Simulated results for family doctor visit (present or absent) – overall, and by age group, gender and ethnicity - compared well to benchmark data (Tables 35 to 38).

Table 35 Percentage visited GP: Simulated results compared to actual data, 2006

	NZ Health Survey 2006	**Simulation 2006***
Visited GP (%)	94.8	96.8

* calibrated for 'practice nurse visit' (as above)

Table 36 Percentage visited GP by age group: Simulated results compared to actual data, 2006

Age Group (years)	GP Visit (%)	
	NZ Health Survey 2006	Simulation 2006*
65-69	91.5	95.9
70-74	96.2	96.6
75-79	96.7	98.0
80-84	97.9	97.9
85+	94.5	95.9

* calibrated for 'practice nurse visit' (as above)

Table 37 Percentage visited GP by gender: Simulated results compared to actual data, 2006

Gender	GP Visit (%)	
	NZ Health Survey 2006	Simulation 2006*
Male	94.1	97.7
Female	95.4	96.1

* calibrated for 'practice nurse visit' (as above)

Table 38 Percentage visited GP by ethnic group: Simulated results compared to actual data, 2006

Ethnic Group	GP Visit (%)	
	NZ Health Survey 2006	Simulation 2006*
European	95.1	96.8
Non-European	92.9	97.3

* calibrated for 'practice nurse visit' (as above)

Simulated results for family doctor visit (categories: 0, 1-2, 3-4, 5-6, 7+) – overall, and by age group and gender - compared well to benchmark data (Tables 39 to 41).

Table 39 Percentage visited GP by number of visits: Simulated results compared to actual data, 2006

GP Visit category	Percentage	
	NZ Health Survey 2006	Simulation 2006*
0 visits	5.4	3.2
1 - 2 visits	23.8	18.0
3-4 visits	35.8	35.2
5-6 visits	16.1	21.2
7+ visits	18.9	22.4

* calibrated for 'practice nurse visit' (as above)

Table 40 Percentage visited GP by number of visits and age group: Simulated results compared to actual data, 2006

Age Group	GP Visit category (%)				
	0 visits	1 - 2 visits	3-4 visits	5-6 visits	7+ visits
			NZ Health Survey 2006		
65-69	8.6	29.3	31.1	16.9	14.2
70-74	3.8	25.5	37.7	15.2	17.7
75-79	4.1	21.0	38.2	16.2	20.6
80-84	2.1	18.8	36.9	15.7	26.5
85+	6.1	13.0	41.2	16.4	23.3
			Simulation 2006*		
65-69	4.1	23.3	35.9	20.1	16.5
70-74	3.4	20.4	37.3	21.6	17.2
75-79	2.0	12.8	33.4	22.8	29.2
80-84	2.1	12.2	33.4	21.2	31.1
85+	4.1	14.4	33.6	19.8	28.1

* calibrated for 'practice nurse visit' (as above)

Table 41 Percentage visited GP by number of visits and gender: Simulated results compared to actual data, 2006

GP Visit category	Percentage	
	Male	Female
	NZ Health Survey 2006	
0 visits	6.0	4.9
1 - 2 visits	27.6	20.5
3-4 visits	35.4	36.2
5-6 visits	15.4	16.8
7+ visits	15.7	21.6
	Simulation 2006*	
0 visits	2.3	3.9
1 - 2 visits	22.0	14.7
3-4 visits	33.5	36.6
5-6 visits	22.1	20.4
7+ visits	20.0	24.4

* calibrated for 'practice nurse visit' (as above)

5.3.8 Public hospital admission

Public hospital admission (present/absent) was the third and final outcome in the health care sequence. Simulated results – overall, and by age group and gender - compared well to benchmark data (Tables 42 to 44).

Table 42 Percentage admitted to public hospital: Simulated results compared to actual data, 2006

	NZ Health Survey 2006	Simulation 2006*
Admitted to Public Hospital (%)	18.1	22.0

* calibrated for 'practice nurse visit' (as above)

Table 43 Percentage admitted to public hospital by age group: Simulated results compared to actual data, 2006

Age Group (years)	Public Hospital Admission (%)	
	NZ Health Survey 2006	Simulation 2006*
65-69	14.1	18.7
70-74	17.5	20.7
75-79	19.7	25.5
80-84	25.2	26.5
85+	19.1	22.5

* calibrated for 'practice nurse visit' (as above)

Table 44 Percentage admitted to public hospital by gender: Simulated results compared to actual data, 2006

Gender	Public Hospital Admission (%)	
	NZ Health Survey 2006	Simulation 2006*
Male	18.8	20.9
Female	17.4	23.0

* calibrated for 'practice nurse visit' (as above)

5.3.9 Informal care

Informal care was simulated first in the social care sequence. Simulated results – overall, and by age group, gender and ethnicity - compared well to benchmark data (Tables 45 to 48).

Table 45 Percentage informal care use (for householders with some disability): Simulated results compared to actual data, 2006

	NZ Disability Survey 2006	Simulation 2006
Informal Care Use (%)	32.8	39.3

Table 46 Percentage informal care use by age group (for householders with some disability): Simulated results compared to actual data, 2006

Age Group (years)	Informal Care Use (%)	
	NZ Disability Survey 2006	Simulation 2006
65-69	26.6	30.5
70-74	25.4	36.3
75-79	31.0	35.6
80-84	37.2	44.9
85+	51.3	58.6

Table 47 Percentage informal care use by gender (for householders with some disability): Simulated results compared to actual data, 2006

Gender	Informal Care Use (%)	
	NZ Disability Survey 2006	Simulation 2006
Male	25.6	30.8
Female	38.8	45.3

Table 48 Percentage informal care use by ethnicity (for householders with some disability): Simulated results compared to actual data, 2006

Ethnic group	Informal care Use (%)	
	NZ Disability Survey 2006	Simulation 2006
European	31.8	49.3
Māori	44.2	51.5
Pacific	55.3	79.7
Asian	48.8	93.3
Other	25.2	49.3

5.3.10 Formal care

Following informal care, formal care was simulated in the social care sequence. Simulated results – overall, and by age group, gender and ethnicity - compared well to benchmark data (Tables 49 to 52).

Table 49 Percentage formal care use (for householders with some disability): Simulated results compared to actual data, 2006

	NZ Disability Survey 2006	Simulation 2006
Formal Care Use (%)	30.0	36.3

Table 50 Percentage formal care use by age group (for householders with some disability): Simulated results compared to actual data, 2006

Age Group (years)	Formal Care Use (%)	
	NZ Disability Survey 2006	Simulation 2006
65-69	17.3	22.5
70-74	23.4	30.4
75-79	30.3	35.7
80-84	39.7	48.9
85+	47.0	55.5

Table 51 Percentage formal care use by gender (for householders with some disability): Simulated results compared to actual data, 2006

Gender	Formal Care Use (%)	
	NZ Disability Survey 2006	Simulation 2006
Male	21.8	28.5
Female	37.0	41.8

Table 52 Percentage formal care use by ethnicity (for householders with some disability): Simulated results compared to actual data, 2006

Ethnic Group	Formal Care Use (%)	
	NZ Disability Survey 2006	Simulation 2006
European	31.9	38.4
Māori	21.2	21.2
Pacific	a	17.6
Asian	a	21.5
Other	24.5	17.0

a unavailable due to confidentiality

5.3.11 Care status

'Care status' for householders was derived from informal care, and formal care variables with the categories: no care, informal care only, both informal and formal care, and formal care only. Simulated results – overall, and by age group, gender and ethnicity - compared well to benchmark data (Tables 53 to 56).

Table 53 Care status (for householders with some disability): Simulated results compared to actual data, 2006

Care Status	Distribution (%)	
	NZ Disability Survey 2006	Simulation 2006
None	48.7	41.5
Informal care only	22.5	22.2
Informal & formal care	10.2	17.1
Formal care only	19.8	19.2

Table 54 Care status by age group (for householders with some disability): Simulated results compared to actual data, 2006

Care Status	Age Group (%)				
	65-69	70-74	75-79	80-84	85+
			NZ Health Survey 2006		
None	60.7	56.8	47.2	36.8	23.4
Informal care only	22.0	19.8	22.5	23.7	28.7
Informal & formal care	4.6	5.4	8.5	13.4	16.2
Formal care only	12.7	18.0	21.8	26.2	31.7
			Simulation 2006		
None	55.8	47.4	43.5	29.6	18.3
Informal care only	21.6	22.2	20.8	21.5	26.2
Informal & formal care	8.9	14.1	14.8	23.3	32.4
Formal care only	13.6	16.3	20.9	25.6	23.1

Table 55 Care status by gender (for householders with some disability): Simulated results compared to actual data, 2006

Care Status	Distribution (%)	
	NZ Disability Survey 2006	Simulation 2006
	Male	
None	60.2	52.4
Informal care only	18.0	19.1
Informal & formal care	7.7	11.8
Formal care only	14.1	16.7
	Female	
None	36.6	33.8
Informal care only	26.4	24.4
Informal & formal care	12.4	20.9
Formal care only	24.6	20.9

Table 56 Care status by ethnicity (for householders with some disability): Simulated results compared to actual data, 2006

Care Status	Distribution (%)	
	NZ Disability Survey 2006	Simulation 2006
	European	
None	46.9	43.1
Informal care only	21.1	18.4
Informal & formal care	10.6	17.6
Formal care only	21.3	20.8
	Non-European [a]	
None	(17300)	(8990)
Informal care only	(10000)	(15111)
Informal & formal care	b	(4173)
Formal care only	b	(2124)

a numbers shown

b unavailable due to confidentiality

The social care module is highly complex (see (Figures 10 to 14). For example, age group and ethnicity may not have been included in statistical models if they were insignificant. Table 55 shows that for the care status category ‘both informal and formal’, simulated results are not comparing well to the benchmark for the 70-74 and 85+ age groups. Table 56 shows that for the care status categories ‘no care’ and ‘informal only’, simulated results are not comparing well to the benchmark for the non-European group.

6. Scenario testing

Our model was designed to address a range of 'what if' questions related to long-term illness and disability, and the use and balance of care. For example, what if there was a policy intervention that could shift the balance of care - what would be its impact?

This counterfactual scenario testing was carried out by simulating a potential outcome via varying relevant factors of interest in the starting sample, while holding other initial factors constant, and observing impact on the outcome. The outcomes of interest were health and social care use respectively. We used the simulated results for the virtual cohort – with no changes made - as the base case.

Key influential factors on care use may be considered as levers through which policy interventions can improve outcomes. For each module, we were able to simulate three situations which address our three corresponding research questions. The outcomes of the policy-related scenarios were the proportions of care users (in the sample of older people) as they changed in response to alterations in model settings.

6.1 Health care module

(1) Base projection of status quo to 2021

We simulate from the starting sample in 2001 forward to 2021 with no changes to inputs or parameters.

(2) Morbidity scenario (2021)

We artificially reduce, by varying degrees, the prevalence and transition probabilities of 'long-term illness' and 'disability') to assess the impact on health service use (practice nurse, family doctor, public hospital admission).

(3) Care scenario (2021).

We artificially increase, by varying degrees, the level of practice nurse (on own) visits to assess the impact on levels of family doctor visits, and public hospital admissions.

6.2 Social care module

(1) Base projection of status quo to 2021

We simulate from the starting sample in 2001 forward to 2021 with no changes to inputs or parameters.

(2) Disability scenario (2021)

We artificially reduce, by varying degrees, the prevalence and the transition probability of 'disability' to assess the impact on social care use (informal care, formal care, and residential care).

(3) Care scenario (2021)

I. We artificially increase the level of informal care use, by varying degrees, to assess the impact on the level of formal care use.

II. We artificially reduce the transition probability to residential care, by varying degrees, to ascertain the amount of increase in community care (informal or formal) that might be required to achieve such an outcome.

6.3 Types of scenario

Six types of scenario were able to be undertaken:

1. Decreasing the baseline prevalence and transition probabilities of long term illness and disability level for householders (including 'newbies' or new entrants) in each 5-year period.
   i. It was necessary to alter both baseline prevalence and transition probabilities for both long-term illness and disability level together for the following reasons:
      i) The original baseline prevalence in the sample aged 65+ was high (long-term illness 85.6%, disability 50.8%) so that any scenario alteration to the transition probability would only be acting on the remaining unaffected proportion of the population. This would result in a minimal effect on outcomes of the scenario.
      ii) If only the prevalence was altered (with an initial reduction occurring in the 2006 iteration) without altering the transition probability, the latter would act over time to bring future values very quickly back to the original prevalence level.
      iii) Alterations to disability level had to occur in tandem with alterations to long-term illness (in the health care module) in order that death was assigned to the correct individuals in the simulation. The probability of death was predicted by socio-demographic variables, and disability level (but not long-term illness). We assumed that long-term illness and disability level were related by the socio-demographic variables.
   ii. Alterations in prevalence of disability (with three levels: mild, moderate, and severe) were implemented by reducing the proportions in each level weighted according to their relative contribution. Their combined reduction was then added to the proportion with no disability.

iii. Alterations in transition probabilities of disability (with four levels: none, mild, moderate, severe) to higher states were implemented as follows. For each row in the matrix of transition probabilities of disability level by age group and gender, the sum of the probabilities for the higher states (i.e. higher than the current value) was multiplied by the proportion required for the alteration. This amount of probability was then added to the probability of staying in the current state. Each higher state had its probability altered, weighted according to its relative contribution. The total amount of alteration in probability values across all higher states was equal to the amount added to the probability of remaining in the current state.

2. Increasing the proportion of householders visiting a practice nurse in the year (applied across the board in each year).

3. Making all householders without a GP visit in the year to have 1-2 visits instead (applied across the board in each year).

4. Altering the proportion of householders with an above average number of GP visits (applied across the board in each year).

5. Increasing levels of informal care among householders with some level of disability (applied across the board in each year).

6. Decreasing the chance of transitioning to residential care from being a householder in each 5-year period. It was not possible to decrease the prevalence of being in residential care as we had limited information on residents so that if they were made to revert to being householders we would have been unable to model their care use. This was deemed acceptable as the original proportion in residential care was small.

7. Discussion

The New Zealand health and social care system, in resource terms, is driven by a complex mix of demand and supply elements, one of which is demographic ageing *(Cumming et al. 2014)*. We developed and tested a model of older age with a set of key drivers and selected care outcomes that may be useful for policy-making. From a technical standpoint, our model provides a data platform that can be further enhanced, and has the potential to be used to test further policy-relevant scenarios *(Ansah et al. 2014; Lagergren 2005; Legare 2011)*. The microsimulation approach employed is advantageous as it can integrate, and enable manipulation of, the effects of variables across multiple equations. A system of inter-dependent processes is represented, where each equation is given its context and influence among other equations. From a substantive standpoint, given the available data, we focussed on a set of specific research questions and associated scenarios of policy relevance to guide the construction of the model.

We were able to construct a microsimulation model of a range of health and social care resources used by older people by combining information from two nationally representative data sources.

7.1 Strengths and limitations

The microsimulation approach, as we have implemented it, has many advantages: it has an empirical basis using individual level data; multiple processes are modelled together, and so can capture social complexity and change; mechanisms are contextualised within a model of the social system; pathways are modelled that may be amenable to policy influence; and policy scenarios can be tested *(Spielauer 2011)*. However, this approach also has limitations: it relies on the availability, quality, and compatibility of data, especially sufficient scope and detail of extant variables to model the core processes and key outcomes of substantive interest *(Cassells, Harding, and Kelly 2006)*. In our study, the official data sources were particularly advantageous as they comprised two series of nationally representative samples so that results from modelling could be generalised to New Zealand's future population. The data limitations in our case were: a small starting sample, self-reported information on use of care (not need nor supply), lack of rich detail, and lack of longitudinal data to derive transition probabilities; and the data did not reflect developments in New Zealand since 2001 *(Cumming et al. 2014)*. Nor are there considerations of changes in social expectations or obligations regarding the provision of care over that period. Data limitations also prevented the modules for health care and social care to be linked. Thus our findings would be squarely based on the data at hand. Nevertheless, the model was able to approximate benchmark data and parameter settings.

In testing a scenario by manipulating a factor of interest in the starting sample, we assumed that other initial conditions and relationships between factors would remain the same. Our model is a simplification of reality – designed to accommodate broad-brush scenarios - but it is nevertheless a source of useful information that can be placed alongside other evidence for policy. Its ability to integrate and contextualise information can address research questions perhaps unanswerable by other means. Ultimately, the model with all its underlying assumptions was designed to provide indicative evidence for policy purposes.

7.2 Conclusion

By bringing together data from various official sources, we were able to construct and test a microsimulation model of older age applied to a substantive policy area. The model can serve as a starting point with the potential to be improved and extended.

8. References

Abello A, Lymer S, Brown L, Harding A, Phillips B. 2008. Enhancing the Australian National Health Survey data for use in a microsimulation model of pharmaceutical drug usage and cost. Journal of Artificial Societies and Social Simulation, 11(3)2.

Anderson RE, Hicks C. 2011. Highlights of contemporary microsimulation. Social Science Computer Review, 29, 1, 3-8.

Ansah JP, Eberlein RL, Love SR, Bautista MA, Thompson JP, Malhotra R, Matchar DB. 2014. Implications of long-term care capacity response policies for an ageing population: a simulation analysis. Health Policy, 116,105–113.

Appleby J. 2013. Spending on health and social care over the next 50 years: Why think long term? London: The King's Fund.

Audit Scotland. 2014. Reshaping care for older people.

Cassells R, Harding A, Kelly S. 2006. Problems and prospects for dynamic microsimulation: a review and lessons for APPSIM. Discussion Paper no. 63. Canberra: National Centre for Social and Economic Modeling, University of Canberra.

Christensen K, Doblhammer G, Rau R, Vaupel JW. 2009. Ageing populations: the challenge ahead. Lancet, 374(9696), 1196-1208.

Coyte PC, Goodwin N, Laporte A. 2008. How can the settings used to provide care to older people be balanced? Denmark: World Health Organisation.

Cumming J, McDonald J, Barr C, Martin G, Gerring Z, Daubé, J. 2014. New Zealand health system review. In Gericke, C.(ed), Health systems in transition. Vol. 4, No. 2. Manila: World Health Organisation.

Davis P, Lay-Yee R, Pearson J. 2010. Using microsimulation to create a synthesised data set and test policy options: the case of health service effects under demographic ageing. Health Policy, 97, 267–274.

Graham P, Blakely T, Davis P, Sporle A, Pearce N. 2004. Compression, expansion or dynamic equilibrium? The evolution of health expectancy in New Zealand. Journal of Epidemiology and Community Health, 58, 659–666.

Gupta A, Harding A. (eds.). 2007. Modelling our future: population ageing, health and aged care. Amsterdam: Elsevier.

Jagger C, Matthews R, Spiers N, Brayne C, Comas-Herrera A, Robinson T, Lindesay J, Croft P. 2006. Compression or expansion of disability? Forecasting future disability levels under changing patterns of diseases. London: King's Fund.

Klevmarken K, Lindgren B. 2008. Simulating an ageing population: a microsimulation approach applied to Sweden. Bingley: Emerald Group Publishing.

Knickman JR, Snell EK. 2002. The 2030 problem: caring for aging baby boomers. Health Services Research, 37(4), 849–884.

Lagergren M. 2005. Whither care of older persons in Sweden? - a prospective analysis based upon simulation model calculations, 2000–2030. Health Policy, 74, 325–334.

Lay-Yee R, Pearson J, Davis P, von Randow M, Pradhan S. 2011. Primary care in an ageing society: developing the PCASO microsimulation model. Technical Report. COMPASS Research Centre, University of Auckland.

Legare J. 2011. Using Statistics Canada LifePaths microsimulation model to project the disability status of Canadian elderly. International Journal of Microsimulation, 4, 3, 48–56.

Li J, O'Donoghue C. 2012. A methodological survey of dynamic microsimulation models. UNU-Merit Working Paper #2012-002. Maastricht University.

Lloyd-Sherlock P, McKee M, Ebrahim S, Gorman M, Greengross S, Prince M, Pruchno R, Gutman G, Kirkwood T, O'Neill D, Ferrucci L, Kritchevsky SB, Vellas B. 2012. Population ageing and health. Lancet 379(9823),1295-1296.

Martini A, Trivellato U. 1997. The role of survey data in microsimulation models for social policy analysis. Labour, 11(1), 83–112.

McNeil C, Hunter J. 2014. The generation strain: collective solutions to care in an ageing society. London: Institute for Public Policy Research.

Milne BJ, Lay-Yee R, Thomas J, Tobias M, Tuohy P, Armstrong A, Lynn R, Davis P, Pearson J, Mannion O. 2014. A collaborative approach to bridging the research-policy gap through the development of policy advice software. Evidence and Policy, 10, 1, 127-136.

Ministry of Health. 1999. Taking the pulse: The 1996/97 New Zealand Health Survey. Wellington: Ministry of Health.

Ministry of Health. 2004. A portrait of health: key results of the 2002/03 New Zealand Health Survey. Wellington: Ministry of Health.

Ministry of Health. 2008. A Portrait of Health. Key results of the 2006/07 New Zealand Health Survey. Wellington: Ministry of Health.

Ministry of Health and Social Affairs, Sweden. 2010. The future need for care: results from the LEV project. Stockholm: Government Offices of Sweden.

Oxley H. 2009. Policies for healthy aging: An overview. Health Working Paper No. 42. Paris: Organisation for Economic Co-operation and Development.

Pearson J, Lay-Yee R, Davis P, O'Sullivan D, von Randow M, Kerse N, Pradhan S. 2011. Primary care in an ageing society: building and testing a microsimulation model for policy purposes. Social Science Computer Review, 29(1), 21–36.

R Development Core Team. 2009. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing.

Rechel B, Doyle Y, Grundy E, McKee M. 2009. How can health systems respond to population ageing? Copenhagen: World Health Organization.

Robine JM, Michel JP. 2004. Looking forward to a general theory on population aging. J Gerontol A Biol Sci Med Sci, 59(6), M590-597.

Rutter CM, Zaslavsky AM, Feuer EJ. 2011. Dynamic microsimulation models for health outcomes: a review. Medical Decision Making, 31:10.

Salmond C, Crampton P. 2012. Development of New Zealand's Deprivation Index (NZDep) and its uptake as a national policy tool. Canadian Journal of Public Health, 103, Suppl. 2, S7-S11.

SAS 9.2, SAS Institute Inc, Cary, North Carolina, USA.

SBC Delivery Group. 2009. Improving outcomes by shifting the balance of care. Scotland: National Health Service, UK.

Spielauer M. 2011. What is social science microsimulation? Social Science Computer Review, 29(1), 9-20.

Spijker J, MacInnes J. 2013. Population ageing: the timebomb that isn't. British Medical Journal, 347:f6598.

Statistics Canada. 2002. A Profile of disability in Canada 2001. Ottawa: Statistics Canada.

Statistics Canada. 2008. The Canadian census mortality follow-up study, 1991 through 2001. Ottawa: Statistics Canada.

Statistics New Zealand. Life Tables. Available online at http://www.stats.govt.nz/browse_for_stats/health/life_expectancy.aspx

Statistics New Zealand. Population statistics. Available online at http://www.stats.govt.nz/browse_for_stats/population.aspx.

Statistics New Zealand. 1999. Disability in New Zealand. Overview of the 1996/97 Surveys. Wellington: Statistics New Zealand.

Statistics New Zealand. 2002. Disability counts 2001. Wellington: Statistics New Zealand.

Statistics New Zealand (2009). Disability and informal care in New Zealand in 2006: Results from the New Zealand Disability Survey. Wellington: Statistics New Zealand.

Statistics New Zealand (2013). Disability and formal supports in New Zealand in 2006: Results from the New Zealand Disability Survey. Wellington: Statistics New Zealand.

Tucker S, Brand C, Wilberforce M, Challis D. 2013. The balance of care approach to health and social care planning: lessons from a systematic literature review. Health Services Management Research, 26(1), 18-28.

Walker A. 2003. Health status, health inequalities and the ability of older Australians to stay in the labour force. National Centre for Social and Economic Modelling, University of Canberra. Paper presented at the International Microsimulation Conference on Population Ageing and Health, Canberra.

Wanless D, Forder J, Fernandez JL, Poole T, Beesley L, Henwood M, Moscone F. 2006. Securing good care for older people: taking a long-term view. London: King's Fund.

Zaidi A, Harding A, Williamson P. (eds). 2009. New frontiers in microsimulation modeling. Public policy and social welfare. Vol. 36. England: Ashgate Publishing.

Zaidi A, Rake K. 2001. Dynamic microsimulation models: a review and some lessons for SAGE. Discussion Paper no. 2. London: Citeseer.

Zucchelli E, Jones AM, Rice N. 2012. The evaluation of health policies through dynamic microsimulation methods. International Journal of Microsimulation, 5(1), 2–20.

9. Appendices

9.1 Statistical sub-model: Disability imputation

Table 57 Statistical sub-model: Disability level

Predictor	Disability level	Estimate	SE	P
Intercept	2	-1.651	0.237	<.0001
Intercept	3	-1.545	0.168	<.0001
Intercept	4	-2.929	0.236	<.0001
Age-group (85+)	2	0.851	0.418	0.042
Age-group (85+)	3	2.573	0.283	<.0001
Age-group (85+)	4	3.105	0.305	<.0001
Age-group (80-84)	2	0.225	0.316	0.4772
Age-group (80-84)	3	1.419	0.190	<.0001
Age-group (80-84)	4	1.176	0.261	<.0001
Age-group (75-79)	2	0.233	0.190	0.2215
Age-group (75-79)	3	0.706	0.171	<.0001
Age-group (75-79)	4	0.422	0.232	0.0689
Age-group (70-74)	2	0.244	0.201	0.224
Age-group (70-74)	3	0.392	0.175	0.0253
Age-group (70-74)	4	0.491	0.215	0.0222
Ethnicity-(Other)	2	-0.467	1.150	0.6849
Ethnicity (Other)	3	0.740	0.575	0.1979
Ethnicity-(Other)	4	2.300	0.614	0.0002
Ethnicity (Pacific)	2	-0.372	0.367	0.31
Ethnicity-(Pacific)	3	-0.774	0.249	0.0018
Ethnicity-(Pacific)	4	1.194	0.243	<.0001
Ethnicity- (Maori)	2	0.130	0.209	0.5345
Ethnicity (Maori)	3	0.410	0.160	0.0105
Ethnicity-(Maori)	4	1.173	0.205	<.0001
Deprivation-quintile (5)	2	0.409	0.283	0.149
Deprivation-quintile (5)	3	0.650	0.222	0.0034
Deprivation-quintile (5)	4	0.731	0.291	0.0121
Deprivation-quintile (4)	2	0.617	0.254	0.0153
Deprivation-quintile (4)	3	0.516	0.165	0.0018
Deprivation-quintile (4)	4	0.636	0.273	0.0197
Deprivation-quintile (3)	2	0.641	0.243	0.0083
Deprivation-quintile (3)	3	0.440	0.194	0.023
Deprivation-quintile (3)	4	0.403	0.278	0.1475
Deprivation-quintile (2)	2	0.293	0.263	0.2647
Deprivation-quintile (2)	3	0.423	0.196	0.0311
Deprivation-quintile (2)	4	0.310	0.298	0.2976
Employed (yes)	2	-0.367	0.272	0.1773
Employed (yes)	3	-1.172	0.230	<.0001
Employed (yes)	4	-2.731	0.749	0.0003

Multinomial regression

N=2751

Reference groups: Age-group (65-69); Ethnicity (European); Deprivation-quintile (1); Employed (no).

9.2 Verification: Disability imputation

Table 58 Distribution of actual vs imputed disability level for householders aged 65+

Disability level	Actual N (weighted)*	Actual % (weighted)*	Imputed N (weighted)	Imputed % (weighted)
None	205400	48.8	190513	49.1
Mild	66400	15.8	57192	14.7
Moderate	115700	27.5	107475	27.7
Severe	33500	8.0	33073	8.5

* NZ Disability Survey 2001

Table 59 Distribution of actual vs imputed disability level for householders by age-group and gender

Age-group	Gender	Disability level	Actual % (weighted)*	Imputed % (weighted)
65-69	Male	None	61.1	63.2
65-69	Male	Mild	16.5	21.8
65-69	Male	Moderate	17.5	11.4
65-69	Male	Severe	4.9	3.6
65-69	Female	None	54.3	54.8
65-69	Female	Mild	16.6	15.4
65-69	Female	Moderate	21.4	23.7
65-69	Female	Severe	7.7	6.2
70-74	Male	None	53.6	55.9
70-74	Male	Mild	16.3	10.7
70-74	Male	Moderate	21.5	26.8
70-74	Male	Severe	8.6	6.7
70-74	Female	None	49.9	50.3
70-74	Female	Mild	19.6	28.5
70-74	Female	Moderate	21.8	17.3
70-74	Female	Severe	8.7	4.0
75-79	Male	None	48.2	58.0
75-79	Male	Mild	14.0	8.4
75-79	Male	Moderate	28.0	26.3
75-79	Male	Severe	9.9	7.3
75-79	Female	None	43.8	51.4
75-79	Female	Mild	18.2	10.7
75-79	Female	Moderate	29.5	32.2
75-79	Female	Severe	8.5	5.6
80-84	Male	None	32.0	32.6
80-84	Male	Mild	12.9	9.7
80-84	Male	Moderate	37.5	43.1
80-84	Male	Severe	17.5	14.7
80-84	Female	None	31.0	41.6
80-84	Female	Mild	10.4	7.8
80-84	Female	Moderate	44.0	38.3
80-84	Female	Severe	14.6	12.3
85+	Male	None	11.9	16.0
85+	Male	Mild	12.2	8.1
85+	Male	Moderate	38.1	42.8
85+	Male	Severe	37.8	33.1
85+	Female	None	13.5	12.0
85+	Female	Mild	8.5	9.9
85+	Female	Moderate	50.0	56.0
85+	Female	Severe	28.1	22.0

* NZ Disability Survey 2001

9.3 Statistical sub-models: Health care module

Table 604 Statistical sub-model: Practice nurse visit

Predictor	Estimate	SE	P
Intercept	-2.443	0.749	0.0011
Age-group (65-74)	0.843	0.282	0.0028
Age-group (75-84)	0.844	0.283	0.0028
Gender (Female)	1.043	0.451	0.0206
Ethnicity (European)	0.788	0.641	0.219
Ethnicity (Maori)	1.033	0.741	0.1632
Ethnicity (Pacific)	-0.737	0.861	0.392
Long-term-illness (Yes)	0.506	0.362	0.1622
Long-term-illness (Yes) * Gender (Female)	-0.919	0.474	0.0526

Logistic regression

N=1289

Reference groups: Age-group (85+); Gender (Male); Ethnicity (Other); Long-term illness (No).

Table 61 Statistical sub-model: Family doctor (GP) visit

Multinomial response: GP visits = 1-2

Predictor	Estimate	SE	P
Intercept	-0.087	1.485	0.9533
Age-group (65-74)	0.202	0.910	0.8244
Age-group (75-84)	0.460	0.943	0.6253
Gender (Female)	0.676	1.087	0.5342
Ethnicity (European)	0.330	0.708	0.6415
Long-term-illness (Yes)	0.179	1.079	0.868
Partnered (yes)	1.779	1.159	0.1247
Practice-nurse-visit (No)	0.958	0.592	0.1057
Long-term-illness (Yes) * Gender (Female)	-0.383	1.050	0.7155
Partnered (Yes) * Gender (Female)	-1.950	0.994	0.0499
Long-term-illness (Yes) * Partnered (Yes)	0.366	1.095	0.738

Multinomial response: GP visits = 3-4

Predictor	Estimate	SE	P
Intercept	0.626	1.358	0.6451
Age-group (65-74)	-0.002	0.869	0.9984
Age-group (75-84)	0.621	0.893	0.4866
Gender (Female)	0.568	1.045	0.5871
Ethnicity (European)	0.016	0.682	0.9816
Long-term-illness (Yes)	0.297	1.003	0.767
Partnered (yes)	0.486	1.130	0.6675
Practice-nurse-visit (No)	1.386	0.588	0.0185
Long-term-illness (Yes) * Gender (Female)	0.158	1.031	0.8779
Partnered (Yes) * Gender (Female)	-1.693	0.964	0.0792
Long-term-illness (Yes) * Partnered (Yes)	1.548	1.069	0.1478

Multinomial response: GP visits = 5-6

Predictor	Estimate	SE	P
Intercept	0.044	1.441	0.9757
Age-group (65-74)	-0.099	0.904	0.9124
Age-group (75-84)	0.719	0.936	0.4426
Gender (Female)	-0.301	1.101	0.7846
Ethnicity (European)	0.088	0.725	0.9031
Long-term-illness (Yes)	-0.360	1.066	0.7359
Partnered (yes)	0.915	1.185	0.4399
Practice-nurse-visit (No)	1.396	0.589	0.0178
Long-term-illness (Yes) * Gender (Female)	1.738	1.082	0.1082
Partnered (Yes) * Gender (Female)	-2.658	1.017	0.009
Long-term-illness (Yes) * Partnered (Yes)	2.027	1.144	0.0764

Multinomial response: GP visits >= 7

Predictor	Estimate	SE	P
Intercept	-2.284	2.113	0.2797
Age-group (65-74)	-0.588	0.885	0.5067
Age-group (75-84)	0.706	0.919	0.4425
Gender (Female)	1.070	1.399	0.4441
Ethnicity (European)	-0.622	0.677	0.3584
Long-term-illness (Yes)	3.657	1.868	0.0503
Partnered (yes)	3.511	1.711	0.0402
Practice-nurse-visit (No)	1.439	0.592	0.0151
Long-term-illness (Yes) * Gender (Female)	-0.160	1.342	0.9051
Partnered (Yes) * Gender (Female)	-1.964	0.998	0.0489
Long-term-illness (Yes) * Partnered (Yes)	-1.647	1.612	0.3069

Multinomial regression

N=1292

Reference groups: GP visits (0); Age-group (85+); Gender (Male); Ethnicity (Other); Long-term illness (No); Partnered (No); Practice-nurse-visit (Yes).

Table 62 Statistical sub-model: Public hospital admission

Predictor	Estimate	SE	P
Intercept	-1.259	0.984	0.2009
Age-group (65-74)	-0.565	1.145	0.6217
Age-group (75-84)	-1.076	1.250	0.3891
Long-term-illness (Yes)	-0.340	0.748	0.6495
GP visits (0)	-1.835	0.768	0.0169
GP visits (1-2)	-2.056	0.356	<.0001
GP visits (3-4)	-0.865	0.214	<.0001
GP visits (5-6)	-0.745	0.241	0.002
Practice-nurse-visit (No)	1.540	0.697	0.0272
Practice-nurse-visit (No) * Age-group (65-74)	-1.434	0.731	0.0497
Practice-nurse-visit (No) * Age-group (75-84)	-1.722	0.768	0.0249
Long-term-illness (Yes) * Age-group (65-74)	1.670	0.967	0.084
Long-term-illness (Yes) * Age-group (75-84)	2.456	1.032	0.0173

Logistic regression

N=1289

Reference groups: Age-group (85+); Long-term-illness (No); GP visits (7+); Practice-nurse-visit (Yes).

9.4 Statistical sub-models: Social care module

These analyses have been undertaken on the subset of older people who are 'householders' (i.e. living in the community and not institutionalised) experiencing some level of disability and thus potentially needing care.

Table 63 Statistical sub-model: Any informal care

Predictor	Estimate	SE	P
Intercept	-3.923	0.468	<.0001
Age-group (85+)	0.617	1.370	0.6524
Age-group (75-84)	-0.037	0.504	0.9408
Gender (Female)	1.115	0.185	<.0001
Ethnicity (Other)	1.658	0.746	0.0262
Ethnicity (Pacific)	0.921	0.287	0.0013
Ethnicity (Maori)	0.153	0.260	0.5567
Deprivation-decile (10)	1.198	0.431	0.0054
Deprivation-decile (9)	1.080	0.449	0.0161
Deprivation-decile (8)	0.717	0.477	0.1332
Deprivation-decile (7)	0.447	0.447	0.3165
Deprivation-decile (6)	0.687	0.469	0.1431
Deprivation-decile (5)	0.905	0.429	0.0348
Deprivation-decile (4)	0.763	0.455	0.0933
Deprivation-decile (3)	0.873	0.352	0.013
Deprivation-decile (2)	0.402	0.482	0.4043
Disability-level (Severe)	8.288	1.196	<.0001
Disability-level (Moderate)	1.440	0.355	<.0001
Age-group (85+) * Disability-level (Severe)	-4.750	1.853	0.0104
Age-group (85+) * Disability-level (Moderate)	0.580	1.424	0.684
Age-group (75-84) * Disability-level (Severe)	-3.182	1.315	0.0155
Age-group (75-84) * Disability-level (Moderate)	0.288	0.547	0.599

Logistic regression
N=1606
Reference groups: Age-group (65-74); Gender (Male); Ethnicity (European); Deprivation-decile (1); Disability-level (None or Mild).

Table 64 Statistical sub-model: Any formal care

Formal care: if no informal care and mild disability level

Predictor	Estimate	SE	P
Intercept	-5.689	2.036	0.0052
Age	0.055	0.028	0.047

Logistic regression

N=428

Formal care: if moderate disability level

Predictor	Estimate	SE	P
Intercept	-5.467	1.251	<.0001
Age	0.058	0.016	0.0003
Gender (Female)	1.204	0.199	<.0001
Ethnicity (Non-European)	-0.766	0.280	0.0061

Logistic regression

N=868

Reference group: Gender (Male); Ethnicity (European).

Formal care: if have informal care and severe disability level

Predictor	Estimate	SE	P
Intercept	0.112	0.155	0.4682
Ethnicity (Non-European)	-1.548	0.332	<.0001

Logistic regression

N=354

Reference group: Ethnicity (European).

9.5 Transition probabilities: Disability, long-term illness, residential care, and partnership

Table 65 Transition probabilities: Disability level ('householders')

Gender-age group		Disability level [a]			
	Current state	State in 5 years' time			
		1	2	3	4
Male (65-69)	1	0.827	0.173	0	0
Female (65-69)	1	0.736	0.264	0	0
Male (70-74)	1	0.796	0.204	0	0
Female (70-74)	1	0.790	0.210	0	0
Male (75-79) [b]	1	0.669	0.011	0.160	0.160
Female (75-79) [b]	1	0.607	0.033	0.180	0.180
Male (80-84) [b]	1	0.254	0.006	0.370	0.370
Female (80-84) [b]	1	0.293	0.007	0.350	0.350
Male (85+) [b]	1	0	0	0	1
Female (85+) [b]	1	0.383	0.017	0.300	0.300
Male (65-69)	2	0	0.294	0.706	0
Female (65-69)	2	0	0.109	0.891	0
Male (70-74)	2	0	0.095	0.905	0
Female (70-74)	2	0	0.338	0.662	0
Male (75-79)	2	0	0.817	0.183	0
Female (75-79)	2	0	0.564	0.436	0
Male (80-84)	2	0	0.523	0.477	0
Female (80-84)	2	0	0.607	0.393	0
Male (85+)	2	0	0	1	0
Female (85+)	2	0	0.268	0.732	0
Male (65-69)	3	0	0	0.586	0.414
Female (65-69)	3	0	0	0.577	0.423
Male (70-74)	3	0	0	0.635	0.365
Female (70-74)	3	0	0	0.813	0.187
Male (75-79)	3	0	0	0.888	0.112
Female (75-79)	3	0	0	0.994	0.006
Male (80-84)	3	0	0	0.646	0.354
Female (80-84)	3	0	0	0.844	0.156
Male (85+)	3	0	0	0.863	0.137
Female (85+)	3	0	0	0.366	0.634
Male (65-69)	4	0	0	0	1
Female (65-69)	4	0	0	0	1
Male (70-74)	4	0	0	0	1
Female (70-74)	4	0	0	0	1
Male (75-79)	4	0	0	0	1
Female (75-79)	4	0	0	0	1
Male (80-84)	4	0	0	0	1
Female (80-84)	4	0	0	0	1
Male (85+)	4	0	0	0	1
Female (85+)	4	0	0	0	1

a. Disability level: 1 (none), 2 (mild), 3 (moderate), 4 (severe)

b. Assumptions were relaxed to allow probabilities other than 0

Table 66 Transition probabilities: Disability level ('residents')

Age group		Disability level [a]	
	Current state	State in 5 years' time	
		3	4
(65-69)	3	0.920	0.080
(70-74)	3	0.121	0.879
(75-79)	3	0.384	0.616
(80-84)	3	0.551	0.449
(85+)	3	0.626	0.374
(65-69) [b]	4	0.410	0.590
(70-74)	4	0	1
(75-79)	4	0	1
(80-84) [b]	4	0.150	0.850
(85+)	4	0	1

a. Disability level: 3 (moderate), 4 (severe)
b. Assumptions were relaxed to allow probabilities other than 0 or 1

Table 67 Transition probabilities: Long-term illness

Gender-age group		Long term illness	
	Current state	State in 5 years' time	
		0	1
Female (65-69)	0	0.482	0.518
Female (65-69)	1	0	1
Male (65-69)	0	0.481	0.519
Male (65-69)	1	0	1
Female(70-74)	0	0.692	0.308
Female(70-74)	1	0	1
Male(70-74)	0	0.958	0.042
Male(70-74) [b]	1	0.040	0.960
Female (75-79)	0	0.566	0.434
Female (75-79)	1	0	1
Male (75-79)	0	0.501	0.499
Male (75-79)	1	0	1
Female (80-84)	0	0.661	0.339
Female (80-84)	1	0	1
Male (80-84)	0	0.604	0.396
Male (80-84)	1	0	1
Female (85+)	0	0.965	0.035
Female (85+) [b]	1	0.020	0.980
Male (85+)	0	0.558	0.442
Male (85+)	1	0	1

a. Long-term illness: 0 (absent), 1 (present)
b. Assumptions were relaxed to allow probabilities other than 0 or 1

Table 68 Transition probabilities: Residential care

Gender-age group		Residential care [a]	
	Current state	State in 5 years' time	
		0	1
Female (65-69)	0	0.977	0.023
Female (65-69)	1	0	1
Male (65-69)	0	0.981	0.019
Male (65-69)	1	0	1
Male (80-84)	0	0.969	0.031
Male(70-74)	1	0	1
Female(70-74)	0	0.967	0.033
Female(70-74)	1	0	1
Female (75-79)	0	0.912	0.088
Female (75-79)	1	0	1
Female (75-79)	0	0.955	0.045
Male (75-79)	1	0	1
Male (75-79)	0	0.806	0.194
Female (80-84)	1	0	1
Female (80-84)	0	0.902	0.098
Male (80-84)	1	0	1
Male(70-74)	0	0.602	0.398
Female (85+)	1	0	1
Male (85+)	0	0.655	0.345
Male (85+)	1	0	1

a. Residential care: 0 (not), 1 (in residential care)

Table 69 Transition probabilities: Partnership status

Gender-age group		Partnership [a]	
	Current state	State in 5 years' time	
		0	1
Male (65-69)	0	0.900	0.100
Female (65-69)	0	1	0
Male(70-74)	0	1	0
Female(70-74)	0	1	0
Male (75-79)	0	1	0
Female (75-79)	0	1	0
Male (80-84)	0	0.974	0.026
Female (80-84)	0	1	0
Male (85+)	0	1	0
Female (85+)	0	1	0
Male (65-69)	1	0.0002	0.9998
Female (65-69)	1	0.030	0.970
Male(70-74)	1	0.020	0.980
Female(70-74)	1	0.174	0.826
Male (75-79)	1	0.131	0.869
Female (75-79)	1	0.257	0.743
Male (80-84)	1	0.0005	0.9995
Female (80-84)	1	0.139	0.861
Male (85+)	1	0.177	0.823
Female (85+)	1	0.474	0.526

a. Partnership: 0 (not partnered), 1 (partnered)

9.6 Verification of transition probabilities: Residential care, and partnership

Table 70 Verification of residential-care transition probabilities

1996		2001			
Age Group	**Gender**	**Actual (in residential care)**		**Simulated (in residential care)**	
		weighted n	weighted %	weighted n	weighted %
1	1	1200	2.1	1336	3.0
1	2	1600	2.7	1154	2.0
2	1	1600	3.8	1611	4.2
2	2	2000	4.00	3437	6.1
3	1	1400	6.4	1125	5.1
3	2	4100	9.8	2763	7.1
4	1	1300	11.9	1462	12.6
4	2	4800	23.3	5287	23.9
5	1	1100	38.5	1476	39.8
5	2	5200	48.8	4894	41.0

Age group: 1 = ’65-69’, 2 = ’70-74’, 3 = ’75-79’, 4 = ’80-84’, 5 = ‘85+’

Gender: 1 = ‘female’, 2 = ‘male’

Table 71 Verification of partnership transition probabilities

1996		2001			
Age Group	**Gender**	**Actual (Partnered)**		**Simulated (Partnered)**	
		weighted n	weighted %	weighted n	weighted %
1	1	40000	80.4	34134	81.3
1	2	31600	57.9	33374	58.9
2	1	30700	79.4	30917	79.2
2	2	19300	41.7	20395	38.8
3	1	13100	68.6	14164	67.2
3	2	9300	27.8	8918	26.6
4	1	6800	67.0	7816	67.6
4	2	2300	16.2	4115	20.5
5	1	1200	53.5	2500	58.4
5	2	CONFIDENTIAL	CONFIDENTIAL	313	3.0

Age group: 1 = ’65-69’, 2 = ’70-74’, 3 = ’75-79’, 4 = ’80-84’, 5 = ‘85+’

Gender: 1 = ‘female’, 2 = ‘male’

*missing data have been excluded

9.7 Transition probabilities: Death by year, ethnicity, gender, and age

Table 72 Transition probabilities: 5-year disability-adjusted mortality – 2001 Non- Māori Males

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.067	0.067	0.158	0.231	0.356
66	0.074	0.074	0.172	0.248	0.384
67	0.083	0.083	0.186	0.264	0.411
68	0.091	0.091	0.202	0.282	0.441
69	0.101	0.101	0.219	0.302	0.471
70	0.112	0.112	0.236	0.319	0.500
71	0.126	0.126	0.253	0.338	0.529
72	0.138	0.138	0.270	0.355	0.556
73	0.153	0.153	0.289	0.373	0.585
74	0.165	0.165	0.306	0.391	0.612
75	0.177	0.177	0.326	0.409	0.640
76	0.188	0.188	0.347	0.430	0.669
77	0.206	0.206	0.372	0.453	0.700
78	0.226	0.226	0.395	0.475	0.729
79	0.253	0.253	0.422	0.499	0.759
80	0.278	0.278	0.447	0.522	0.786
81	0.306	0.306	0.471	0.543	0.809
82	0.352	0.352	0.494	0.563	0.831
83	0.388	0.388	0.520	0.584	0.852
84	0.419	0.419	0.542	0.602	0.869
85	0.457	0.457	0.567	0.623	0.888
86	0.489	0.489	0.593	0.644	0.905
87	0.536	0.536	0.619	0.664	0.920
88	0.585	0.585	0.647	0.687	0.934
89	0.645	0.645	0.669	0.704	0.945
90	0.705	0.705	0.687	0.717	0.952
91	0.731	0.731	0.701	0.726	0.958
92	0.759	0.759	0.714	0.735	0.963
93	0.798	0.798	0.729	0.745	0.967
94	0.848	0.848	0.751	0.765	0.974
95	0.905	0.905	0.767	0.780	0.978
96	0.904	0.904	0.784	0.795	0.982
97	0.879	0.879	0.807	0.818	0.987
98	0.703	0.703	0.828	0.839	0.990
99	0.727	0.727	0.848	0.858	0.993

Table 73 Transition probabilities: 5-year disability-adjusted mortality – 2001 Non- Māori Females

Age	**Disability level**				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.032	0.032	0.111	0.335	0.420
66	0.035	0.035	0.117	0.339	0.428
67	0.039	0.039	0.122	0.342	0.437
68	0.043	0.043	0.128	0.347	0.446
69	0.047	0.047	0.136	0.354	0.460
70	0.053	0.053	0.144	0.363	0.474
71	0.062	0.062	0.153	0.372	0.490
72	0.071	0.071	0.163	0.381	0.506
73	0.081	0.081	0.173	0.389	0.520
74	0.091	0.091	0.182	0.396	0.533
75	0.104	0.104	0.194	0.407	0.550
76	0.115	0.115	0.206	0.416	0.566
77	0.130	0.130	0.218	0.426	0.582
78	0.146	0.146	0.232	0.437	0.601
79	0.166	0.166	0.247	0.448	0.618
80	0.190	0.190	0.262	0.460	0.637
81	0.214	0.214	0.278	0.471	0.653
82	0.243	0.243	0.294	0.482	0.671
83	0.276	0.276	0.314	0.497	0.691
84	0.307	0.307	0.334	0.510	0.710
85	0.344	0.344	0.355	0.524	0.730
86	0.386	0.386	0.380	0.542	0.752
87	0.430	0.430	0.406	0.560	0.774
88	0.480	0.480	0.431	0.576	0.793
89	0.538	0.538	0.458	0.592	0.812
90	0.592	0.592	0.484	0.608	0.829
91	0.637	0.637	0.508	0.620	0.844
92	0.673	0.673	0.535	0.634	0.859
93	0.718	0.718	0.561	0.647	0.872
94	0.753	0.753	0.588	0.663	0.886
95	0.783	0.783	0.618	0.681	0.901
96	0.805	0.805	0.653	0.707	0.919
97	0.794	0.794	0.685	0.731	0.933
98	0.821	0.821	0.715	0.760	0.947
99	0.845	0.845	0.743	0.787	0.959

Table 74 Transition probabilities: 5-year disability-adjusted mortality – 2001 Māori Males

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.146	0.146	0.322	0.448	0.631
66	0.156	0.156	0.339	0.465	0.655
67	0.169	0.169	0.356	0.481	0.678
68	0.180	0.180	0.375	0.499	0.702
69	0.195	0.195	0.395	0.517	0.726
70	0.209	0.209	0.412	0.533	0.746
71	0.228	0.228	0.430	0.548	0.766
72	0.243	0.243	0.446	0.560	0.782
73	0.261	0.261	0.462	0.573	0.799
74	0.273	0.273	0.476	0.583	0.812
75	0.283	0.283	0.490	0.593	0.825
76	0.290	0.290	0.504	0.602	0.837
77	0.306	0.306	0.520	0.614	0.851
78	0.323	0.323	0.535	0.625	0.863
79	0.350	0.350	0.555	0.641	0.878
80	0.377	0.377	0.577	0.657	0.893
81	0.407	0.407	0.598	0.674	0.907
82	0.461	0.461	0.621	0.692	0.920
83	0.501	0.501	0.646	0.711	0.933
84	0.534	0.534	0.666	0.725	0.943
85	0.571	0.571	0.687	0.741	0.952
86	0.600	0.600	0.708	0.756	0.960
87	0.645	0.645	0.727	0.770	0.967
88	0.689	0.689	0.749	0.786	0.973
89	0.743	0.743	0.765	0.797	0.978
90	0.796	0.796	0.780	0.806	0.981
91	0.818	0.818	0.791	0.814	0.984
92	0.841	0.841	0.803	0.821	0.986
93	0.874	0.874	0.815	0.830	0.988
94	0.913	0.913	0.835	0.847	0.991
95	0.953	0.953	0.849	0.860	0.993
96	0.953	0.953	0.863	0.873	0.995
97	0.936	0.936	0.882	0.891	0.996
98	0.794	0.794	0.899	0.907	0.998
99	0.815	0.815	0.914	0.921	0.998

Table 75 Transition probabilities: 5-year disability-adjusted mortality – 2001 Māori Females

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.095	0.095	0.306	0.717	0.814
66	0.102	0.102	0.312	0.713	0.815
67	0.110	0.110	0.315	0.705	0.812
68	0.115	0.115	0.317	0.694	0.807
69	0.119	0.119	0.319	0.684	0.802
70	0.127	0.127	0.320	0.673	0.797
71	0.138	0.138	0.321	0.661	0.791
72	0.149	0.149	0.322	0.649	0.785
73	0.160	0.160	0.322	0.636	0.778
74	0.169	0.169	0.322	0.623	0.771
75	0.182	0.182	0.326	0.616	0.769
76	0.192	0.192	0.332	0.610	0.768
77	0.210	0.210	0.339	0.607	0.770
78	0.227	0.227	0.351	0.610	0.777
79	0.253	0.253	0.365	0.615	0.786
80	0.283	0.283	0.381	0.622	0.798
81	0.313	0.313	0.398	0.630	0.809
82	0.349	0.349	0.416	0.638	0.820
83	0.387	0.387	0.436	0.648	0.832
84	0.421	0.421	0.454	0.654	0.842
85	0.458	0.458	0.471	0.660	0.851
86	0.498	0.498	0.492	0.669	0.861
87	0.539	0.539	0.512	0.677	0.871
88	0.584	0.584	0.531	0.683	0.879
89	0.637	0.637	0.552	0.692	0.888
90	0.686	0.686	0.574	0.701	0.898
91	0.725	0.725	0.595	0.708	0.906
92	0.756	0.756	0.620	0.719	0.915
93	0.796	0.796	0.644	0.729	0.924
94	0.826	0.826	0.670	0.743	0.934
95	0.851	0.851	0.699	0.759	0.944
96	0.868	0.868	0.732	0.782	0.956
97	0.862	0.862	0.764	0.807	0.966
98	0.888	0.888	0.798	0.838	0.976
99	0.912	0.912	0.830	0.867	0.984

Table 76 Transition probabilities: 5-year disability-adjusted mortality – 2001 Pacific Males

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.111	0.111	0.252	0.359	0.526
66	0.124	0.124	0.275	0.385	0.563
67	0.139	0.139	0.300	0.412	0.600
68	0.154	0.154	0.327	0.441	0.639
69	0.173	0.173	0.356	0.471	0.678
70	0.192	0.192	0.383	0.499	0.712
71	0.216	0.216	0.411	0.526	0.745
72	0.237	0.237	0.437	0.550	0.773
73	0.262	0.262	0.463	0.574	0.800
74	0.281	0.281	0.488	0.595	0.823
75	0.299	0.299	0.513	0.617	0.845
76	0.315	0.315	0.539	0.639	0.866
77	0.340	0.340	0.567	0.662	0.886
78	0.366	0.366	0.591	0.682	0.902
79	0.400	0.400	0.617	0.703	0.917
80	0.429	0.429	0.640	0.720	0.930
81	0.460	0.460	0.658	0.733	0.939
82	0.511	0.511	0.675	0.744	0.946
83	0.546	0.546	0.693	0.757	0.954
84	0.574	0.574	0.706	0.764	0.959
85	0.606	0.606	0.721	0.774	0.964
86	0.629	0.629	0.736	0.783	0.969
87	0.667	0.667	0.749	0.791	0.973
88	0.706	0.706	0.765	0.801	0.977
89	0.754	0.754	0.776	0.807	0.980
90	0.801	0.801	0.785	0.812	0.982
91	0.819	0.819	0.792	0.814	0.984
92	0.838	0.838	0.799	0.818	0.985
93	0.868	0.868	0.808	0.823	0.987
94	0.905	0.905	0.824	0.836	0.990
95	0.945	0.945	0.835	0.846	0.991
96	0.944	0.944	0.847	0.856	0.993
97	0.922	0.922	0.864	0.873	0.995
98	0.767	0.767	0.879	0.888	0.996
99	0.786	0.786	0.894	0.902	0.997

Table 77 Transition probabilities: 5-year disability-adjusted mortality – 2001 Pacific Females

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.064	0.064	0.213	0.564	0.669
66	0.070	0.070	0.223	0.568	0.678
67	0.078	0.078	0.231	0.571	0.686
68	0.084	0.084	0.239	0.572	0.693
69	0.090	0.090	0.249	0.576	0.702
70	0.100	0.100	0.259	0.580	0.710
71	0.114	0.114	0.269	0.583	0.718
72	0.127	0.127	0.279	0.585	0.726
73	0.140	0.140	0.287	0.585	0.730
74	0.153	0.153	0.294	0.583	0.733
75	0.168	0.168	0.304	0.585	0.740
76	0.181	0.181	0.314	0.585	0.745
77	0.199	0.199	0.324	0.586	0.751
78	0.216	0.216	0.335	0.589	0.758
79	0.239	0.239	0.346	0.590	0.764
80	0.264	0.264	0.358	0.593	0.771
81	0.288	0.288	0.369	0.593	0.777
82	0.317	0.317	0.380	0.595	0.782
83	0.348	0.348	0.394	0.598	0.790
84	0.376	0.376	0.406	0.600	0.796
85	0.409	0.409	0.421	0.605	0.805
86	0.447	0.447	0.441	0.614	0.817
87	0.488	0.488	0.462	0.623	0.830
88	0.535	0.535	0.484	0.633	0.842
89	0.590	0.590	0.507	0.645	0.855
90	0.642	0.642	0.531	0.657	0.868
91	0.684	0.684	0.554	0.667	0.878
92	0.717	0.717	0.579	0.679	0.890
93	0.760	0.760	0.604	0.691	0.901
94	0.792	0.792	0.631	0.705	0.913
95	0.819	0.819	0.660	0.722	0.925
96	0.839	0.839	0.694	0.746	0.940
97	0.829	0.829	0.725	0.770	0.951
98	0.853	0.853	0.754	0.797	0.963
99	0.875	0.875	0.781	0.822	0.972

Table 78 Transition probabilities: 5-year disability-adjusted mortality – 2006 Non- Māori Males

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.054	0.054	0.127	0.188	0.295
66	0.059	0.059	0.138	0.201	0.317
67	0.066	0.066	0.149	0.214	0.340
68	0.072	0.072	0.162	0.229	0.366
69	0.081	0.081	0.177	0.246	0.394
70	0.089	0.089	0.191	0.262	0.421
71	0.101	0.101	0.207	0.279	0.450
72	0.112	0.112	0.223	0.296	0.479
73	0.126	0.126	0.241	0.315	0.509
74	0.137	0.137	0.259	0.333	0.539
75	0.149	0.149	0.278	0.353	0.570
76	0.160	0.160	0.299	0.374	0.602
77	0.177	0.177	0.323	0.398	0.637
78	0.195	0.195	0.346	0.420	0.668
79	0.220	0.220	0.372	0.444	0.702
80	0.243	0.243	0.398	0.468	0.732
81	0.270	0.270	0.423	0.491	0.761
82	0.316	0.316	0.449	0.515	0.788
83	0.353	0.353	0.478	0.540	0.816
84	0.386	0.386	0.503	0.562	0.839
85	0.423	0.423	0.530	0.585	0.861
86	0.454	0.454	0.556	0.606	0.880
87	0.498	0.498	0.579	0.624	0.896
88	0.543	0.543	0.604	0.644	0.911
89	0.599	0.599	0.623	0.658	0.922
90	0.658	0.658	0.640	0.670	0.931
91	0.685	0.685	0.654	0.680	0.938
92	0.715	0.715	0.669	0.691	0.945
93	0.759	0.759	0.686	0.704	0.952
94	0.816	0.816	0.713	0.727	0.962
95	0.881	0.881	0.733	0.746	0.969
96	0.884	0.884	0.755	0.766	0.975
97	0.859	0.859	0.783	0.794	0.982
98	0.680	0.680	0.809	0.820	0.987
99	0.709	0.709	0.833	0.844	0.991

Table 79 Transition probabilities: 5-year disability-adjusted mortality – 2006 Non- Māori Females

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.027	0.027	0.097	0.296	0.374
66	0.030	0.030	0.102	0.301	0.384
67	0.034	0.034	0.107	0.306	0.393
68	0.038	0.038	0.113	0.311	0.403
69	0.041	0.041	0.120	0.318	0.417
70	0.047	0.047	0.128	0.327	0.432
71	0.055	0.055	0.136	0.336	0.447
72	0.063	0.063	0.145	0.345	0.463
73	0.072	0.072	0.154	0.353	0.477
74	0.081	0.081	0.163	0.360	0.490
75	0.092	0.092	0.174	0.370	0.507
76	0.102	0.102	0.185	0.380	0.523
77	0.117	0.117	0.197	0.390	0.541
78	0.131	0.131	0.210	0.402	0.560
79	0.151	0.151	0.225	0.414	0.579
80	0.173	0.173	0.241	0.428	0.600
81	0.197	0.197	0.257	0.440	0.619
82	0.226	0.226	0.274	0.454	0.640
83	0.259	0.259	0.296	0.472	0.665
84	0.292	0.292	0.317	0.489	0.688
85	0.330	0.330	0.340	0.506	0.711
86	0.372	0.372	0.367	0.526	0.736
87	0.417	0.417	0.393	0.545	0.760
88	0.467	0.467	0.419	0.562	0.781
89	0.525	0.525	0.446	0.579	0.801
90	0.581	0.581	0.474	0.596	0.820
91	0.628	0.628	0.500	0.611	0.837
92	0.667	0.667	0.529	0.628	0.854
93	0.716	0.716	0.558	0.644	0.870
94	0.753	0.753	0.589	0.663	0.886
95	0.786	0.786	0.622	0.684	0.903
96	0.810	0.810	0.659	0.713	0.922
97	0.802	0.802	0.693	0.740	0.937
98	0.830	0.830	0.726	0.771	0.952
99	0.855	0.855	0.756	0.799	0.963

Table 80 Transition probabilities: 5-year disability-adjusted mortality – 2006 Māori Males

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.124	0.124	0.279	0.394	0.568
66	0.132	0.132	0.292	0.407	0.589
67	0.142	0.142	0.306	0.420	0.609
68	0.151	0.151	0.320	0.433	0.629
69	0.162	0.162	0.335	0.447	0.651
70	0.173	0.173	0.349	0.459	0.670
71	0.188	0.188	0.364	0.472	0.689
72	0.201	0.201	0.379	0.485	0.708
73	0.218	0.218	0.396	0.500	0.729
74	0.232	0.232	0.414	0.515	0.749
75	0.245	0.245	0.434	0.533	0.771
76	0.258	0.258	0.458	0.553	0.795
77	0.281	0.281	0.485	0.577	0.821
78	0.305	0.305	0.510	0.599	0.843
79	0.336	0.336	0.536	0.621	0.864
80	0.363	0.363	0.559	0.640	0.881
81	0.391	0.391	0.578	0.654	0.894
82	0.438	0.438	0.596	0.667	0.906
83	0.472	0.472	0.615	0.681	0.917
84	0.500	0.500	0.630	0.691	0.925
85	0.532	0.532	0.648	0.703	0.934
86	0.557	0.557	0.665	0.715	0.942
87	0.596	0.596	0.680	0.724	0.949
88	0.636	0.636	0.698	0.737	0.956
89	0.687	0.687	0.711	0.745	0.961
90	0.739	0.739	0.722	0.751	0.965
91	0.760	0.760	0.731	0.755	0.968
92	0.784	0.784	0.741	0.761	0.971
93	0.821	0.821	0.753	0.770	0.975
94	0.868	0.868	0.775	0.789	0.980
95	0.920	0.920	0.791	0.803	0.984
96	0.920	0.920	0.808	0.819	0.987
97	0.898	0.898	0.832	0.842	0.991
98	0.734	0.734	0.853	0.863	0.994
99	0.759	0.759	0.873	0.882	0.996

Table 81 Transition probabilities: 5-year disability-adjusted mortality – 2006 Māori Females

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.075	0.075	0.248	0.627	0.731
66	0.081	0.081	0.255	0.626	0.735
67	0.089	0.089	0.261	0.623	0.737
68	0.095	0.095	0.267	0.618	0.737
69	0.100	0.100	0.273	0.615	0.740
70	0.109	0.109	0.279	0.612	0.742
71	0.121	0.121	0.286	0.609	0.743
72	0.133	0.133	0.292	0.605	0.744
73	0.146	0.146	0.296	0.600	0.744
74	0.157	0.157	0.301	0.594	0.743
75	0.172	0.172	0.310	0.593	0.747
76	0.184	0.184	0.319	0.592	0.752
77	0.203	0.203	0.329	0.594	0.758
78	0.221	0.221	0.342	0.598	0.767
79	0.246	0.246	0.356	0.603	0.776
80	0.274	0.274	0.370	0.608	0.785
81	0.300	0.300	0.382	0.611	0.792
82	0.330	0.330	0.395	0.613	0.798
83	0.363	0.363	0.410	0.617	0.807
84	0.391	0.391	0.423	0.619	0.813
85	0.425	0.425	0.437	0.623	0.820
86	0.463	0.463	0.457	0.631	0.832
87	0.503	0.503	0.477	0.639	0.842
88	0.548	0.548	0.497	0.648	0.853
89	0.602	0.602	0.519	0.657	0.864
90	0.653	0.653	0.542	0.668	0.876
91	0.694	0.694	0.564	0.677	0.886
92	0.727	0.727	0.589	0.689	0.897
93	0.770	0.770	0.615	0.701	0.908
94	0.802	0.802	0.642	0.716	0.919
95	0.829	0.829	0.672	0.733	0.931
96	0.849	0.849	0.707	0.758	0.945
97	0.840	0.840	0.737	0.782	0.956
98	0.864	0.864	0.766	0.809	0.967
99	0.885	0.885	0.793	0.834	0.975

Table 82 Transition probabilities: 5-year disability-adjusted mortality - 2011 Males

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.052	0.052	0.124	0.184	0.289
66	0.052	0.052	0.122	0.179	0.284
67	0.052	0.052	0.120	0.173	0.279
68	0.052	0.052	0.118	0.168	0.275
69	0.052	0.052	0.116	0.163	0.272
70	0.083	0.083	0.178	0.245	0.397
71	0.084	0.084	0.174	0.237	0.390
72	0.084	0.084	0.170	0.228	0.381
73	0.085	0.085	0.166	0.220	0.374
74	0.083	0.083	0.161	0.212	0.366
75	0.137	0.137	0.258	0.328	0.538
76	0.133	0.133	0.253	0.318	0.530
77	0.133	0.133	0.249	0.310	0.524
78	0.132	0.132	0.243	0.300	0.514
79	0.135	0.135	0.238	0.291	0.507
80	0.226	0.226	0.372	0.440	0.702
81	0.227	0.227	0.361	0.424	0.688
82	0.240	0.240	0.350	0.407	0.674
83	0.243	0.243	0.340	0.391	0.661
84	0.241	0.241	0.327	0.373	0.644
85	0.389	0.389	0.492	0.545	0.829
86	0.384	0.384	0.478	0.526	0.817
87	0.392	0.392	0.464	0.506	0.804
88	0.400	0.400	0.454	0.491	0.795
89	0.419	0.419	0.440	0.472	0.781
90	0.572	0.572	0.554	0.584	0.880
91	0.566	0.566	0.536	0.561	0.867
92	0.564	0.564	0.519	0.540	0.853
93	0.577	0.577	0.504	0.521	0.842
94	0.609	0.609	0.499	0.514	0.838
95	0.763	0.763	0.591	0.604	0.905
96	0.738	0.738	0.582	0.595	0.899
97	0.674	0.674	0.582	0.595	0.899
98	0.452	0.452	0.582	0.595	0.899
99	0.452	0.452	0.582	0.595	0.899

Table 83 Transition probabilities: 5-year disability-adjusted mortality - 2011 Females

Age	Disability level				
	Living in households				Residential
	None	Mild)	Moderate	Severe	
65	0.029	0.029	0.103	0.312	0.393
66	0.029	0.029	0.098	0.291	0.372
67	0.030	0.030	0.093	0.270	0.351
68	0.029	0.029	0.089	0.251	0.330
69	0.029	0.029	0.085	0.233	0.312
70	0.046	0.046	0.126	0.323	0.427
71	0.048	0.048	0.121	0.302	0.405
72	0.050	0.050	0.115	0.281	0.384
73	0.051	0.051	0.110	0.261	0.362
74	0.051	0.051	0.104	0.240	0.339
75	0.084	0.084	0.160	0.344	0.475
76	0.084	0.084	0.152	0.320	0.450
77	0.085	0.085	0.145	0.298	0.427
78	0.085	0.085	0.139	0.278	0.405
79	0.087	0.087	0.132	0.258	0.383
80	0.166	0.166	0.231	0.413	0.583
81	0.168	0.168	0.220	0.386	0.556
82	0.172	0.172	0.210	0.360	0.529
83	0.175	0.175	0.202	0.337	0.505
84	0.176	0.176	0.193	0.313	0.479
85	0.317	0.317	0.328	0.490	0.695
86	0.322	0.322	0.317	0.463	0.671
87	0.325	0.325	0.306	0.437	0.647
88	0.332	0.332	0.295	0.411	0.623
89	0.345	0.345	0.285	0.388	0.600
90	0.486	0.486	0.388	0.501	0.731
91	0.491	0.491	0.377	0.476	0.710
92	0.490	0.490	0.370	0.455	0.693
93	0.500	0.500	0.363	0.435	0.676
94	0.502	0.502	0.358	0.419	0.662
95	0.611	0.611	0.449	0.507	0.761
96	0.494	0.494	0.357	0.401	0.649
97	0.454	0.454	0.357	0.395	0.645
98	0.454	0.454	0.357	0.395	0.645
99	0.454	0.454	0.357	0.395	0.645

9.8 Validation: Disability level – New Zealand vs Canada; and Official vs simulated Māori and non- Māori population numbers by year, age group, and gender

Table 84 Disability level by gender and age group: Comparison between New Zealand and Canada, 2001

	Disability Level			
CANADA (A Profile of Disability in Canada 2001 - Statistics Canada 2002)				
	'none'	**'mild'**	**'moderate +severe'**	**'very severe'**
Male 65-74	69.8	13.5	13.7	3.0
Male 75+	47.9	17.9	25.4	8.9
Female 65-74	68.0	11.4	17.3	3.3
Female 75+	45.9	16.9	28.2	9.1
NEW ZEALAND (NZ Disability Survey 2001 – Statistics NZ)				
	'none'	**'mild'**	**'moderate'**	**'severe'**
Male 65-74	57.5	16.4	19.4	6.7
Male 75+		Confidential		
Female 65-74	52.0	18.1	21.6	8.3
Female 75+	33.7	13.6	38.5	14.2

Table 859 Official versus calibrated simulated Māori population numbers by year and age group - Males

Year	NZ Projected Population* (Simulated)				
	Age group				
	65-69	70-74	75-79	80-84	85+
2011	5900	4500	2500	1200	500
	(5900)	(4500)	(2500)	(1200)	(500)
2016	8000	4900	3500	1700	800
	(8000)	(4900)	(3500)	(1700)	(800)
2021	9700	6800	3900	2400	1300
	(9700)	(6800)	(3900)	(2400)	(1300)

* Statistics NZ

Table 86 Official versus calibrated simulated Māori population numbers by year and age group - Females

Year	NZ Projected Population* (Simulated)				
	Age group				
	65-69	70-74	75-79	80-84	85+
2011	6600	5100	3100	1700	1000
	(6600)	(5100)	(3100)	(1700)	(1000)
2016	9200	5800	4200	2300	1500
	(9200)	(5800)	(4200)	(2300)	(1500)
2021	11200	8100	4800	3200	2200
	(11200)	(8100)	(4800)	(3200)	(2200)

* Statistics NZ

Note: Simulated numbers have been calibrated to correspond to the official numbers.

Table 87 Official versus calibrated simulated Non-Māori population numbers by year and age group - Males

Year	NZ Projected Population* (Simulated)				
	Age group				
	65-69	70-74	75-79	80-84	85+
2011	82100	65100	46700	34800	25000
	(82100)	(65100)	(46700)	(34800)	(25000)
2016	104200	76900	57200	36400	31900
	(104200)	(76900)	(57200)	(36400)	(31900)
2021	109900	98300	68500	46000	36400
	(109900)	(98300)	(68500)	(46000)	(36400)

* Statistics NZ

Note: Simulated numbers have been calibrated to correspond to the official numbers.

Table 88 Official versus calibrated simulated Non-Māori population numbers by year and age group - Females

Year	NZ Projected Population* (Simulated)				
	Age group				
	65-69	70-74	75-79	80-84	85+
2011	85600	70500	53600	44900	46600
	(85600)	(70500)	(53600)	(44900)	(46600)
2016	109100	82200	65100	45400	52000
	(109100)	(82200)	(65100)	(45400)	(5200)
2021	116500	105600	76800	56200	55900
	(116500)	(105600)	(76800)	(56200)	(55900)

* Statistics NZ

Note: Simulated numbers have been calibrated to correspond to the official numbers.