Population Ageing and Government Health Expenditures in New Zealand, 1951-2051

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New Zealand Treasury

Working Paper 04/14

September 2004

THE TREASURY
Kaitohutohu Kaupapa Rawa

NZ TREASURY WORKING PAPER 04/14

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MONTH/YEAR

September 2004

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ACKNOWLEDGEMENTS

The authors would like to thank the referees of the paper for their helpful comments. We would also like to thank participants at both Treasury and Ministry of Health internal seminars. Staff from the Policy Coordination and Development and the Health sections of the Treasury provided some useful feedback on earlier drafts.

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Abstract

The paper uses a simulation model to assess the effects of population ageing on government health expenditures in New Zealand. Population ageing is defined to include disability trends and “distance to death”; government health expenditures are defined to include both acute and long-term care. The model results suggest that population ageing is associated with a large increase in expenditure share of people aged 65 and over, which rises from about 29% of total government health expenditure in 1951 to 63% in 2051. Analysis of demographic and health trends over the period 1951 to 2002 suggests, however, that these trends account for only a small proportion of the total growth in health expenditure. Most expenditure growth is attributable to other factors, such as an expansion in the range of treatments provided, and increases in input prices such as wages. Growth in this non-demographic component of health expenditures has reached 3-4% per year over recent years. Projection results for the period 2002 to 2051 suggest that restraining government expenditure on health to 6-12% of GDP would require long-run growth rates for the non-demographic component of health expenditure that are significantly lower than current rates. In other words, future demographic changes may be less threatening than is often assumed, but it would still not be possible to maintain current growth rates for government health expenditure and avoid substantial increases in the ratio between expenditure and GDP.

JEL CLASSIFICATION C53 - Forecasting and Other Model Applications
H51 - Government Expenditures and Health

KEYWORDS Fiscal projections; Government health expenditure; Health status; New Zealand

Executive Summary

The average person aged 65 or over currently costs New Zealand's public health system about five times as much as the average person under 65. Over the next 50 years, the proportion of the population aged 65 and over is expected to double. As a result, population ageing will influence government health care expenditures. This will raise concern about intergenerational equity of such spending, and pose complex ethical issues about investment in health sector interventions. This report updates and extends previous work carried out by the Treasury and Ministry of Health on this issue. It outlines a model developed in the Treasury to project future health expenditure.

The international empirical evidence suggests that per capita spending on health care is highest for disabled people, and for those in the last year of their life. Per capita spending rises with age because older people are more likely to be in at least one of these two categories. There is a measured increase in the disability rate in the population – this reflects the increase in the proportion of older people, who are more likely to be disabled. The international evidence suggests a decline, over time, in disability rates.

One approach to projecting health expenditure is to predict the combined effects of population ageing and cost increases. Sources of cost increases include technological change, broadening the range of conditions treated, and wage rises. In the model outlined in this report, the rate of growth in real per capita expenditure is assumed to vary between age groups. The model is innovative in that it also makes allowance for the improving health status of the population over time, and for the fact that a large proportion of lifetime costs are associated with the last year of life (the 'distance to death' effect). Both of these factors should work to reduce demographic pressure on health spending.

The model reported in this paper uses cost and population values for 2002, extracted from the Ministry of Health's Expenditure Database, and from Statistics New Zealand's 2001 Census and Vitals Data and its 2001 Household Disability Survey. Plausible ranges for growth in GDP per worker, trends in fertility, migration, mortality and disability rates were taken from the following sources: Treasury's long term fiscal model; Statistics New Zealand projections; and a systematic review of the international literature on disability trends, respectively.

Health spending is also driven by non-demographic factors – things such as wage and cost increases, increases in the coverage of the public health system and technological advances. We use historical averages (derived by backcasting our model) for this factor to examine its influence. The modelling shows that overall health spending is more sensitive to assumptions about this factor than to assumptions about demographic influences.

Anticipated improvement in the health status of future generations has complex effects, as the net effect of mortality improvement is to *increase* spending pressure (mortality improvement contributes to population ageing and increases the length of time lived with disability – swamping the 'distance to death' effect which acts to decrease spending).

Our model shows that demographic pressure is relatively low until 2020 but that it increases after this time. If overall government health spending is to stay within reasonable levels of GDP then non-demographic spending will need to be significantly lower than historical rates. For example, to keep government health spending under 9%

of GDP until 2050, growth in non-demographic spending would need to average 1.5%. To keep spending under 12% of GDP, growth in non-demographic spending would need to average 2%. This is lower than the average historical rate of growth in non-demographic spending: over the last 50 years it has been 2.35%; and over the last five years it has been 4%. This rate is clearly unsustainable over the longer term if the government is to maintain its current fiscal objectives.

The model results also suggests that population ageing will significantly change the spread of spending through the population. The expenditure share of those aged 65 and over has risen from about 29% of total government health expenditure in 1951 to about 40% today. Our model suggests that this will rise further to 63% in 2051. The political economy effects of having 25% of the population aged over 65 are noted but not examined.

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1 Introduction

The average 30 year old New Zealand male currently receives about $900 of health care per year from the government health care system; the average 90 year old male receives about $16,000 of care. Statistics New Zealand projections suggest that the number of 30 year old males will increase by about 20% over the next 25 years, while the number of 90 year old males will increase by 150%. The apparent implication of such numbers is that population ageing is about to add substantially to government health expenditures. Health currently accounts for about 20% of government expenditure, so rapid increases in the cost of health care has serious implications for government finances.

But there is room for scepticism, or at least reservations, about a close link between population ageing and spending pressures. Econometric studies have produced mixed findings on the relationship between changes in countries' age structure and changes in their health expenditures (O'Connell 1996). More fundamentally, the focus on age structure may be misplaced, because underlying health status, rather than age itself, may be the real determinant of the demand for health care, and the relationship between age and health status varies over time.

This paper presents a model of how the demographic and health profile of the New Zealand population is changing, and how these changes create pressures for increased government health expenditure. The model is applied to historical data, to estimate the contribution of demographic and health changes to historical growth in expenditures. The model is also used to construct projections for the coming decades. These projections are used to answer questions such as the following: Will demographic and health trends create greater spending pressures in the future than they have in the past? Could improvements in health status offset the extra spending pressures created by population ageing? How will expenditure be distributed among different age groups? How sustainable are recent trends in health expenditures?

Projecting decades into the future requires some strong assumptions. There are also some important gaps in data on current health expenditures in New Zealand. The result is that the projections presented in this report are necessarily simple and approximate. Imperfect as they are, however, the projections are still preferable to the alternatives, which are to forgo discussions of generational equity and fiscal sustainability altogether, or to base such discussions entirely on intuition and implicit assumptions.

It is important to emphasize that this report deals exclusively with *government* health expenditure: it makes no attempt to model private health expenditure. Government health expenditure currently makes up about 80% of total health expenditure in New Zealand (Ministry of Health 2004). It should also be noted that the definition of government health expenditures used in this report differs from the definition used in many overseas studies, in that it includes long-term care as well as acute care. In New Zealand, acute and long-term care are currently funded through the same appropriation, "Vote Health".

The next section of the paper reviews some of the links between ageing, health, and health expenditures. Section 3 summarises previous models of health expenditure. Section 4 describes the main elements of our model, and Section 5 describes how the model has been operationalized. Sections 3 to 5 are all relatively brief and non-technical; the mathematical details are reserved for the Appendix. Section 6 presents results from the historical analysis and projections, and the final section summarizes the report's findings and draws out some of the implications.

The model has been constructed by an inter-disciplinary team from the Treasury and the Ministry of Health.

2 The relationship between ageing, health, and health expenditures

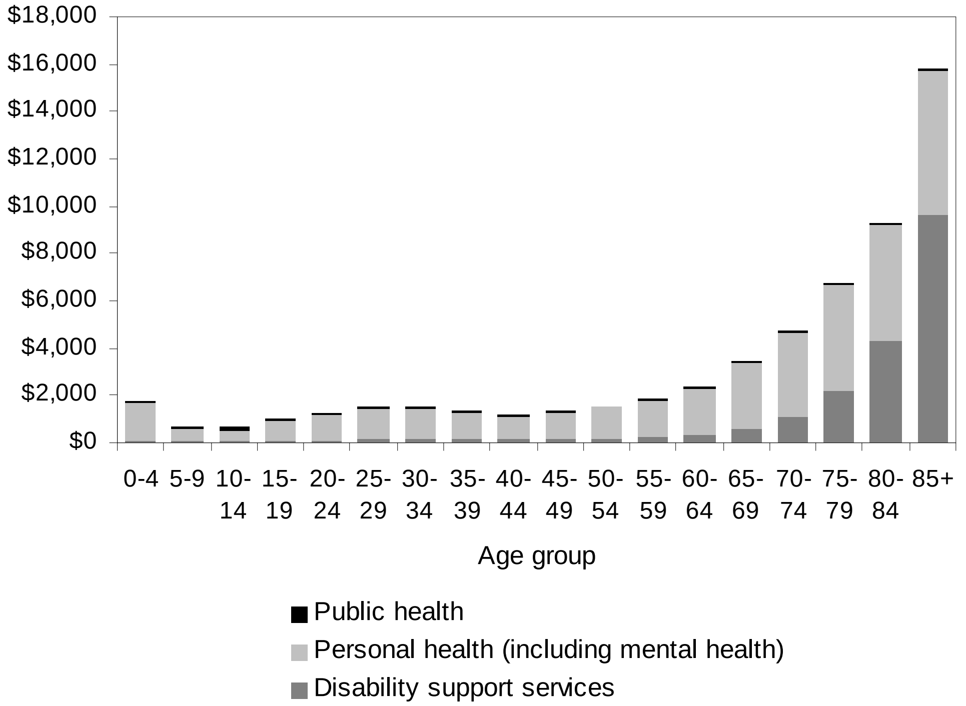
2.1 Why is there a cross-sectional relationship between age and health expenditure?

Figure 1 shows the cross-sectional relationship between age and government health expenditure in New Zealand, in the financial year 2001/02. The item "public health" covers things such as national campaigns for anti-smoking. The service group "disability support services" includes items such as home support, residential care, and equipment, while "personal health" includes primary, secondary and tertiary medical care. Expenditure on both of the latter types of service increases with age, though the most pronounced increases occur with disability support services. For people aged 85 and over, 61% of health expenditure is accounted for by disability support services.

Why does health expenditure increase with age? The answer seems to be that people in poor health receive more expenditure than people in good health, and that the prevalence of poor health rises with age. There are, of course, many ways of measuring health. The measures that we use in our model are "distance to death" and disability.

Studies in the United States and Canada have found that, on average, people who are about to die make greater use of health services than those who are not. In other words, "distance to death" can predict health expenditure better than "distance from birth" (ie age). The link between distance from death and expenditure is especially strong for acute care (Lubitz and Riley 1993, McGrail, Green, Barer, Evans, Hertman and Normand 2000, Miller 2001, Yang, Norton and Stearns 2003).

Figure 1 – Annual government health expenditure by age and service group (males and females combined), 2001/02



Source – Ministry of Health

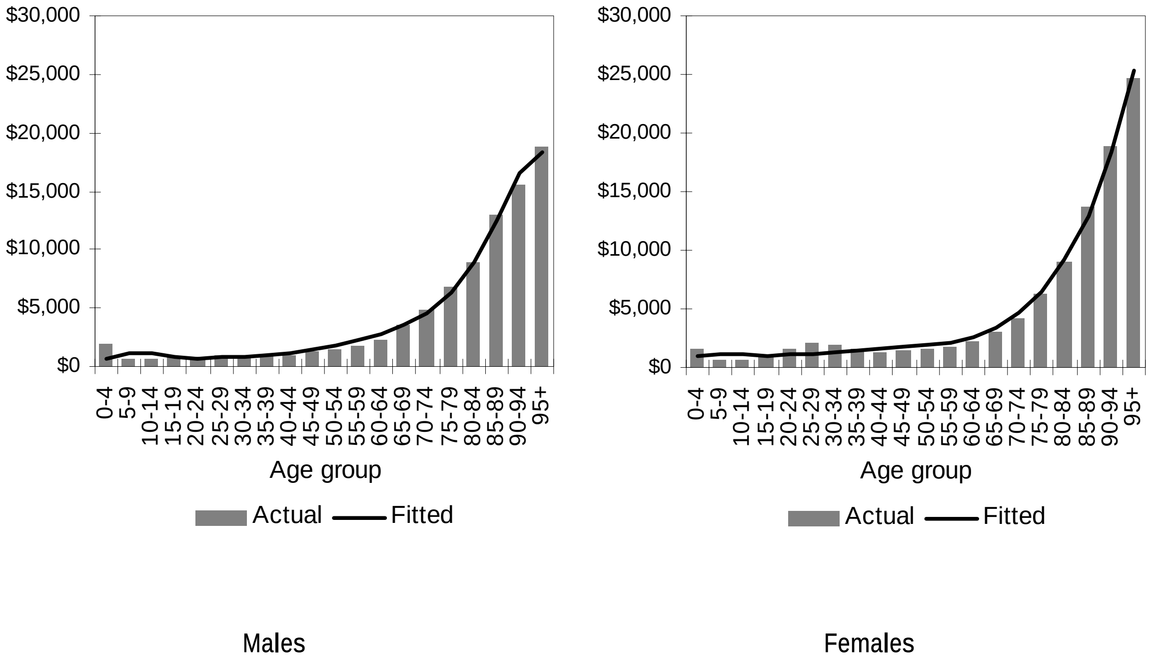
Similarly, overseas studies have found that people with disabilities, measured by difficulties carrying out everyday activities such as dressing or climbing stairs, are relatively intensive users of health services (Cutler and Sheiner 1998, National Research Council 2001). Cutler and Sheiner (1998: Table 12) find that, once statistical controls for the effects of distance and death and disability are used, age *per se* explains little of the variation in Medicare expenditures in the United States.

The overseas studies use data on individual patients. There have, as yet, been no comparable studies in New Zealand. However, some evidence for the salience of disability and distance from death for government health expenditures is provided by Figure 2. The vertical lines show government health expenditure by age and sex. The black lines show expenditure predicted by a simple statistical model in which expenditure is a function of disability and distance to death. The underlying data on expenditure, disability, and distance to death are shown in Appendix Table 1.

The disability prevalence estimates were calculated from the 2001 Post-Censal Disability Survey, which covered a representative sample of over 4000 people with disabilities, including the population in residential care[1]. The survey defined disability as a functional limitation lasting for at least six months and requiring personal assistance or a complex assistive device. Two levels of severity are recognized: non daily (intermittent) and daily (continuous). We use a severity-weighted average of the two, with conditions requiring daily assistance receiving twice the weight of conditions that do not.

[1] A description of the survey is available on the Statistics New Zealand website, www.stats.govt.nz.

Figure 2 – How well do distance to death and disability prevalence predict the pattern of health expenditure by age?



Note – For males the fitted model is $c_i = 132 + 22747d_i + 11484u_i$ (R^2=0.992) where c_i, d_i, and u_i are, respectively, per capita expenditure, proportion in the last year of life, and proportion with a disability, for people in age group i. For females the fitted model is $c_i = 601 + 54673d_i + 9517u_i$ (R^2=0.994).

The model matches actual expenditure remarkably well. It does have some implausible features: for instance the estimated coefficients for males and females are suspiciously different. But the results do provide strong circumstantial evidence that distance to death and disability prevalence are both important to explaining variation in health expenditure in New Zealand.

2.2 Measurement of population health

In this study, a reference to "improving health" implies a reduction in disability rates or mortality rates within each age group. Table 1 shows a stylized example of what we would call "improving health": disability rates for "young" and "old" both fall between periods 1 and 2. In this example, however, disability rates calculated over the total population actually increase. The reason for this apparent paradox is simple: the proportion of the population in the high-disability older age group is increasing. A failure to distinguish between changing age-specific rates and changing overall rates is, however, a common source of confusion in discussions of health and ageing.

Table 1 – Stylized example of health trends during population ageing

	Population			Disability rate			Number of people with disabilities		
Time	Young	Old	Total	Young	Old	Total	Young	Old	Total
Period 1	70	20	90	10.0%	50.0%	18.9%	7.0	10.0	17.0
Period 2	80	40	120	9.0%	45.0%	21.0%	7.2	18.0	25.2

2.3 International evidence on disability trends

It is difficult to predict the net effect of medical progress on age-specific disability rates. Some new technologies have led to increased disability rates: the standard example is coronary care, which has reduced the case fatality of heart attack, but in so doing has created an "epidemic" of heart failure. However, other technologies such as drugs to reduce hypertension (the major risk factor for stroke) have helped reduce disability rates. Similarly, it is difficult to predict the net effect on disability of conflicting population health trends such as increasing obesity and declining smoking rates. The only way to resolve the uncertainty is to look at longitudinal data on disability.

We have carried out a systematic review of longitudinal studies from New Zealand and elsewhere. Appendix 3 provides details on the methodology of the review, and on the studies that were included. The studies reviewed came to different conclusions. For instance, comparison of the 1996 and 2001 Post-Censal Disability Surveys in New Zealand suggested that disability rates were approximately constant during that period, while Census data from Australia appeared to imply that rates had risen somewhat. The highest-quality studies, covering the longest periods, were conducted in the United States. These studies all suggested that significant declines in disability rates had been occurring.

3 Previous simulation models of ageing and health expenditures

Three distinguishing features of the model used in our study are: (i) it is highly aggregative: (ii) it is based on cohorts rather than individuals; and (iii) it divides the population into a finite number of groups. This section describes earlier health expenditure models that share these features. Some research on health expenditure has used alternative modelling strategies (Manton and Stallard 1992, Wanless 2002), but these alternative models are not discussed here.

3.1 A stylized example

Table 2 builds on the simple example presented in Table 1 above. The population is disaggregated into two groups, “young” and “old”. The first and second columns of the table show launch year and projected population sizes for these two groups. The third and fourth columns show observed and projected costs per person. Projected values for total expenditures are obtained by multiplying and summing.

Table 2 – A stylized health expenditure projection

	Population			Costs per person		
	Young	Old	Total	Young	Old	Total expenditure
Launch year	70	20	90	$10	$30	70×$10+20×$30=$1300
Projected (fixed costs)	80	40	120	$10	$30	80×$10+40×$30=$2000
Projected (costs×3)	80	40	120	$10×3=$30	$30×3=$90	80×$30+40×$90=$6000

The "Projected (fixed costs)" row shows what expenditure would be if costs per person, within each age group, were to remain at their initial level. In the example shown, total expenditure is higher in the fixed cost projection than it is in the initial year. This increase reflects the growth in total population, and the growth in the population share of the high-cost older age group, which rises from 22% (20/90) to 33% (40/120). Fixed-cost projections are one method for measuring spending pressures due to population change.

The "Projected (costs x 3)" row shows what expenditure would be if cost per person, within each age group, were to increase by a factor of three. Costs can increase for many reasons, including, for instance, technological change, increases in wages for health workers, and an expansion in the range of conditions that are treated.

Many studies also project GDP, to permit the calculation of expenditure as a percent of GDP. The GDP projections use the same method as the expenditure projections, with GDP per employee (ie labour productivity) taking the place of cost per person. In general, a rise in the population share of older people has opposing effects on health expenditure per capita and GDP per capita: it raises the former and lowers the latter. Appendix 2 provides further details on the projection of GDP[2].

3.2 Some published models

Table 3 summarizes the main features of some published studies that use the same modelling strategy as we do[3]. For comparison, information on our model is shown at the bottom of the table. The models differ from each other, and from that of Table 2, mainly in the way that they disaggregate the population. Some classify the population only by age and sex, while others add one or more extra dimensions, to capture changes in health status.

Johnston and Teasdale (1999) classify the population by age and sex. Past trends for cost growth are estimated by "back-casting": by calculating the cost growth that the model suggests would be necessary to reconcile observed population trends with observed expenditure trends. Johnston and Teasdale back-cast over the period 1978-1998, and obtain an average growth rate for underling costs of 0.9% per year. They use a rounded-up figure of 1.0% in their projections. They adopt Treasury's assumption that labour productivity grows at 1.5% per year. With these assumptions, government health expenditure, as defined in the report, reaches 8.4% of GDP in 2051, compared with 6.5% in 2001. The New Zealand Treasury, in its Long-Term Fiscal Model, and the Australian Treasury, in its Intergenerational Report, use essentially the same methodology as

[2] We use real GDP throughout this paper.

[3] The structural equivalence is not always immediately apparent. For a demonstration that Johnston's and Teasdale's (1999) model is equivalent, see Appendix 2.

Johnston and Teasdale. Some of the differences in the implementation are described in the table.

Table 3 – Models for projecting health expenditures

Model	Scope	Disaggregation of population	Assumption about annual growth rate: Disability prevalence	Costs per person	GDP per employee	Results
Johnston and Teasdale (1999)	Government health expenditure, New Zealand	-Age -Sex	NA	1.0%	1.0%	Expenditure/GDP rises to 8.4% in 2050/51
NZ Treasury's Long-Term Fiscal Model*	Government health expenditure, New Zealand	-Age -Sex	NA	1.5%	1.5%	Expenditure/GDP rises to 8.5% in 2049/50
Australian Commonwealth Treasury's Intergenerational Report**	Government health expenditure, Australia	-Age -Sex	NA	Varies by expenditure category and, for one item, by age and sex	1.75%	Expenditure/GDP rises from 4% in 2001/02 to 8% in 2041/42.
Cutler and Sheiner (1998)	Medicare, United States	-Age -Sex -Distance from death -Disability	-1.0% and -1.5%	(i) Equals growth rate of GDP; (ii) Equals growth rate of GDP + 2.5%	NA	Depending on the assumptions about underlying costs, expenditure / GDP rises from 1.7% in 1992 to 2.5% or 10.4% in 2050
Jacobzone, Cambois, and Robine (2000)	Government expenditure on long-term care, 9 OECD countries	-Age -Sex -Disability -Institutionized	Varies by country	Equal to growth rate of GDP	NA	Results for 2000-2020 vary from large increase in Japan to small decrease in US
Miller (2001)	Medicare, United States	-Age -Sex -Distance from death (10 categories)	NA	NA	NA	Rising age at death partly offsets effect of population ageing
Present study	*Government health expenditure, New Zealand*	*-Age* *-Sex* *-Distance from death* *-Disability*	*-0.5%*	*1.5%*	*1.5%*	*[See Section 6]*

*The latest version of the Long-Term Fiscal Model can be downloaded from http://www.treasury.govt.nz/ltfm/default.asp
**A description of the model methodology and results is available at http://www.budget.gov.au/2002-03/bp5/html/index.html.
Note – 'NA' denotes 'not applicable.'

Cutler and Sheiner (1998) were an important source of ideas for our model and use a finer typology than just age and sex. Within each age-sex group, they distinguish between people who are in their last year of life (decedents), and those who are not (survivors). Survivors are further disaggregated by their degree of disability. They are therefore able to relate changes in health expenditure to changes in disability and distance to death. As Section 2.1 argues, disability and distance to death are more fundamental determinants of service use than age.

Jacobzone, Cambois, and Robine (2000) distinguish between people with disabilities and people without, and between those who are in institutions providing long-term care and those who are not. Separate projections are constructed for each of the nine OECD countries in the study. The projections extrapolate forward recent trends in each country's disability and institutionalization rates. Miller (2001) uses age, sex, and distance to death. His typology by distance to death is very detailed: he distinguishes between people who are less than one year from death, less than two years from death, and so on up to 10 years.

4 The structure of the model

This section sets out the basic structure of our model. A more detailed and technical description is given in Appendix 2. Section 5 describes how the required values are derived from available data. The model contains two sub-models: a "demographic-health" sub-model (corresponding to the two "population" columns in Table 2); and an "expenditure" sub-model (corresponding to the "cost per capita" and "total expenditure" columns in Table 2).

4.1 The demographic-health sub-model

The population is divided by sex, and by 20 age groups (0-4, 5-9, and so on up to 95 and over.) Each age-sex group is subdivided by distance to death—"decedents" who will die during the following year versus "survivors" who will not—and by disability. This yields the four health statuses shown in Table 4. Changes over time in the health of an age-sex group, and hence its demands on government health services, are captured by changes in the relative size of the four health statuses. With two sexes, 20 age groups, and four health statuses, the model partitions the population into a total of 160 (=2×20×4) different categories. Overall changes in population structure and health are captured by changes in the number of people in these 160 categories.

Table 4 – Health statuses used in the model

Non-disabled survivors	Non-disabled decedents
Disabled survivors	Disabled decedents

4.2 The expenditure sub-model

Each of the 160 categories is assigned a value for government health expenditure per person per year. Total expenditure is calculated by multiplying the costs per person by the number of people in each category, and summing, just as in the stylized model of

Table 2. Expenditure on a particular age group is calculated by restricting the summation to that age group.

Costs per person are assumed to rise at the same rate for all 160 age-sex-health categories. New Zealand lacks longitudinal data on expenditure by age and health status. Overseas evidence on whether costs grow faster for some population groups than others is mixed. For instance, Freund and Smeeding (2002: Figure 2) show that old people's costs per capita grew faster than young people's costs per capita in the United States in the period 1954-1987, while costs grew at roughly the same rate for young and old in England and Wales in the period 1982-1992.

Assuming that per capita costs grow at the same rate in all age-sex-health categories conveys our ignorance about actual differences between categories, in the past and the future. As shown in Appendix 2, the use of identical growth rates also allows us to express growth in total expenditure as the sum of growth in three underlying components:

$$\text{Growth rate for expenditure} = \text{Growth rate for population size} + \text{Growth rate for ageing and health effect} + \text{Growth rate for coverage and price effect} \quad (1)$$

The "ageing and health effect" is equivalent to the "ageing adjustment" in the Ministry of Health model (Johnston and Teasdale 1999: 9) and the "demographic adjustment" in the Long-Term Fiscal Model (2000: 42), except that it incorporates changes in disability and distance-to-death, and not just changes in age structure. The ageing and health effect measures the extent to which spending must increase to offset unfavourable changes in the demographic or health profile of the population. For instance, if there is a rise in the proportion of the population that is disabled, this will be captured by a rise in the ageing and health effect.

The "coverage and price" effect is an "everything else" term, measuring expenditure growth beyond that required to offset demographic and trends. Growth in coverage and price reflects things such as expansion in the range of treatments offered, changes in the efficiency of service provision, changes in demand, and rises in wages or pharmaceutical prices. Rapid growth in the coverage and price term does not necessarily translate to rapid improvements in health: it may simply reflect a rise in input prices. Similarly, slow growth does not necessarily translate to deterioration in health: it may reflect an improvement in efficiency. In this study, we make no attempt to measure the extent to which growth in coverage and price translates to better health.

Studies of health expenditures sometimes apply the label "technology" to variables like our "coverage and price" term. We avoid this usage because it obscures the role of non-technological determinants such as changes in demand and input costs.

4.3 Expenditure as a percent of GDP

As described in Section 3.1, the GDP projections have essentially the same structure as the expenditure projections. This means that a modified version of Equation 1 can be used to study changes in health expenditure as a percent of GDP:

$$\text{Growth rate for health expenditure as \% GDP} = \text{Growth rate for ageing and health effect} + \text{Growth rate for coverage and price effect} - \text{Growth rate for GDP per capita} \quad (2)$$

This expression is derived in Appendix 2. Population size does not appear in the equation because it contributes to both expenditure (the numerator) and GDP (the denominator), and therefore cancels out. Population ageing tends to increase the growth rate of the ageing and health effect, and reduce the growth rate for GDP per capita.

4.4 Back-casting and projecting

The model can be used for back-casting, to extract information from historical data, or for projections, to give a sense of future developments. Table 5 summarizes the inputs and outputs in either case.

Table 5 – Comparison of back-casting and projections

	Main inputs	Main outputs
Back-casting	Data for 1950/51-2001/02 on population and mortality rates by age and sex; total expenditure; and GDP Assumptions about disability trends, 1950/51-2001/02 Data and assumptions on costs by age, sex, and health status in 2001/02	The components of trends in total expenditure and per capita, 1950/51-2001/02 The components of trends in the ratio of expenditure to GDP, 1950/51-2001/02 The distribution of expenditure by age, 1950/51-2001/02
Projections	Assumptions about mortality, fertility, migration, trends, 2001/02-2050/51 Assumptions about trends in costs by age, sex, and health status, 2002-2051	Population by age, sex, and health status, 2001/02-2050/51 Trends in total and per capita expenditure, 2001/02-2050/51 Trends in the ratio of expenditure to GDP, 2001/02-2050/51 The distribution of expenditure by age, 2001/02-2050/51

4.5 Simpler versions of the model

As discussed in Section 3.2, different models of health expenditures classify the population in different ways, some more detailed than others. In addition to the full version described already, we have constructed three versions that use simpler classifications. These are summarized in Table 6. All four versions are run on the same underlying data, though the simpler versions fail to exploit some of this data, such as the proportion of the population in the last year of life.

Table 6 – Methods of classification used in different versions of the model

Version of model	Age and sex	Disability	Distance to death
Age-sex	Yes		
Disability	Yes	Yes	
Distance-to-death	Yes		Yes
Full	Yes	Yes	Yes

Comparing results from the "age-sex" and the "disability" versions, for instance, provides a measure of potential biases in expenditure projections that leave out disability decline. It also gives some sense of the potential importance of disability decline.

4.6 Incorporating for the effect of health expenditure on health status

This study examines the effect of health status on government health expenditure. Obviously, government health expenditure also affects health status: that is the motivation for making the expenditures.

It would, in principle, be possible to construct a model that explicitly allowed for two-way interactions between government health expenditures and health status. Such a model would, however, require estimates of the effectiveness of current and future medical technologies, and of the contribution of other influences on population health, such as lifestyle and environmental change. These matters are intensely debated in the medical literature.

We have chosen a more modest approach. We project future health status by simply extrapolating historical trends, and remain agnostic on the relative contributions of government health expenditure and other determinants to these trends. This is the approach taken by studies similar to ours, as described in Section 3.

5 Operationalizing the model

5.1 The demographic-health sub-model

5.1.1 Mortality

The back-casting requires estimates of historical mortality rates, which were obtained from Statistics New Zealand and from unpublished vital registration data. The projections require assumptions about future mortality rates. Most health expenditure models use the assumptions constructed by the official statistical agency. However, most statistical agencies, including Statistics New Zealand, derive values for future mortality rates indirectly, via assumptions about life expectancy. Because mortality rates play a key role in our model, we have decided to use a method that is more direct.

We have assumed that mortality rates for both sexes, all age groups, and all years decline at a constant rate in future years. Our model is similar to that of Lee and Carter (1992), except that Lee and Carter allow mortality rates to decline faster in some age groups than in others. An obvious disadvantage of our assumption that mortality rates decline at the same pace in all age groups is that it reduces the model's realism. It may not, however, reduce the model's predictive power excessively, as analysis of historical trends shows that age groups that have experienced rapid declines in one period have not necessarily experienced rapid declines in subsequent periods (Booth, Maindonald and Smith 2002). The assumption also has several advantages: it is consistent with our treatment of disability; it is simple and transparent; and it allows alternative mortality scenarios to be easily summarized.

The problem remains, however, of choosing sensible values for the rate of decline. Our benchmark assumption is that the annual rate of decline for the period 2002-2051 equals the annual rate of decline for the period 1951-2002. There is room for disagreement on how to calculate the rate of decline, but, as described in Appendix 2, we have settled on a value of 1.5%. We also carry out sensitivity tests using a rate of decline of 1.0%.

5.1.2 Disability

As described in Section 2.1, estimates of disability prevalence in 2001 were calculated from data in the Post-Censal Disability Survey. Our baseline assumption for the back-casting is that disability prevalence within each age-sex group was constant over the period 1951-2002, though we conduct sensitivity tests using alternative assumptions.

For the projections, we assume that disability rates decline at a constant rate in all age-sex groups. We based our choice for a rate of decline on the systematic review described briefly in Section 2.3. Given the long time periods and the methodological rigour of the United States studies, we decided to place considerable weight on them. The US studies all found rapid disability decline. Accordingly, we decided that a plausible range for disability decline in New Zealand was between 0% and 1% a year. Our benchmark assumption is that disability rates decline at 0.5% per year, though we also carry out sensitivity tests based on an assumption that disability rates are constant.

There is some tension between the assumption that disability was constant until 2002 and the assumption that it declines after 2002. In the absence of long-term data, however, any choice of starting date for disability decline is unavoidably arbitrary. Sensitivity testing also shows that the choice of starting date has little effect on the major substantive result from the back-casting (which, to anticipate Section 6.2, is that changes in coverage and price dominate health expenditure trends.)

5.1.3 Population by age and sex

For the back-casting we use Statistics New Zealand data. For future years, population projections are constructed by the model itself, based on the assumed rate of mortality decline, and on Statistics New Zealand's medium fertility and migration assumptions. The population projections use a standard cohort-component methodology (Preston, Heuveline and Guillot 2001)[4].

5.1.4 Health status within each age-sex group

With the assumptions and data described so far, it is possible to calculate the number of people in each age-sex group who are disabled, and the number who will die in the following year. Further data or assumptions are required, however, to calculate the numbers who are disabled *and* in their last year of life, disabled *and* not in their last year of life, and so on.

Our assumption is that the percentage of decedents in an age-sex group who are not disabled equals the proportion who die of "injury", according to the cause-of-death statistics for 2001/02. Essentially, we assume that everyone who is in their last year of life

[4] We use the 'median' fertility assumption and the '5,000 migrants per year' migration assumption from the 2001-base projection round. Information on these assumptions can be obtained from Statistics New Zealand's website www.stats.govt.nz. Standard projection methods could not be applied exactly, because we required annual projections with 5-year age groups, and because some of the necessary data on the open-ended age group (95 and over) were missing or contradictory.

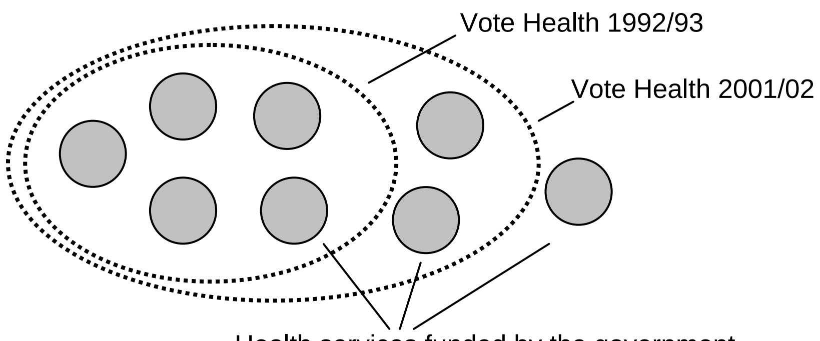
is disabled, except for those who die of injury. An exception is that we assume that half of the people aged 65 and over who have non-injury deaths are disabled, on the grounds that many "injuries" among older people are actually attributable to underlying chronic conditions[5]. Under these assumptions, approximately 94% of decedents are disabled, and 6% of disabled people are decedents in 2001[6].

5.2 The expenditure sub-model

5.2.1 Health expenditure series

The government pays for a variety of services that contribute in some way to health, ranging from hospitals to public health campaigns to medical schools. Not all such services are paid for under "Vote Health", the budget allocated to the Ministry of Health. The allocation of services to Votes changes over time. For instance, between 1992/93 and 2001/02 Disability Support Services was transferred out of Vote Social Welfare into Vote Health. These services accounted for about 8 per cent of Vote Health expenditure in 2001/02. For a schematic representation of the relationship between health services and Votes, see Figure 3.

Figure 3 – The relationship between Vote Health and government health services



When, in our projections, we refer to "government health expenditures" we mean expenditure by the government on the basket of services that were provided through Vote Health in 2001/02. Ideally, we would like to construct an historical expenditure series based on exactly this definition.

We have two sets of data with which to construct such series. The first is annual figures on Vote Health in the period 1950/51 to 2001/02, assembled by the Treasury from official year books. The second is annual estimates for "total net transfers" to Vote Health for the period 1993/94 to 2001/02. These transfers indicate expenditure on services moved from other Votes into Vote Health since 1992/93.

To construct our historical expenditure series from these data, we have made two assumptions. The first is that the range of services provided under Vote Health remained the same over the period from 1950/51 to 1992/93. The second is that the ratio between expenditure on services provided through Vote Health in 1993/94 and expenditure on

[5] An additional modification is that we assume that the ratio of non-disabled decedents to disabled decedents equals the ratio of non-disabled to disabled for all people of that age and sex if this overall ratio is lower.
[6] There is no special reason why these figures add up (approximately) to 100%: it is a statistical coincidence.

services provided through Vote Health in 2001/02 remained the same throughout the period 1950/51 to 2001/02. A different way of stating the same assumption is that growth rates for both those services always provided through Vote Health and those services previously provided under other Votes are the same throughout the period.

Our assumptions are unlikely to be fully met in practice. The resulting expenditure series are nevertheless better suited to our purposes than the unadjusted Vote Health series, particularly for the 1990s. Details on the calculations are shown in Appendix 2.

5.2.2 Per capita health costs in 2001/02

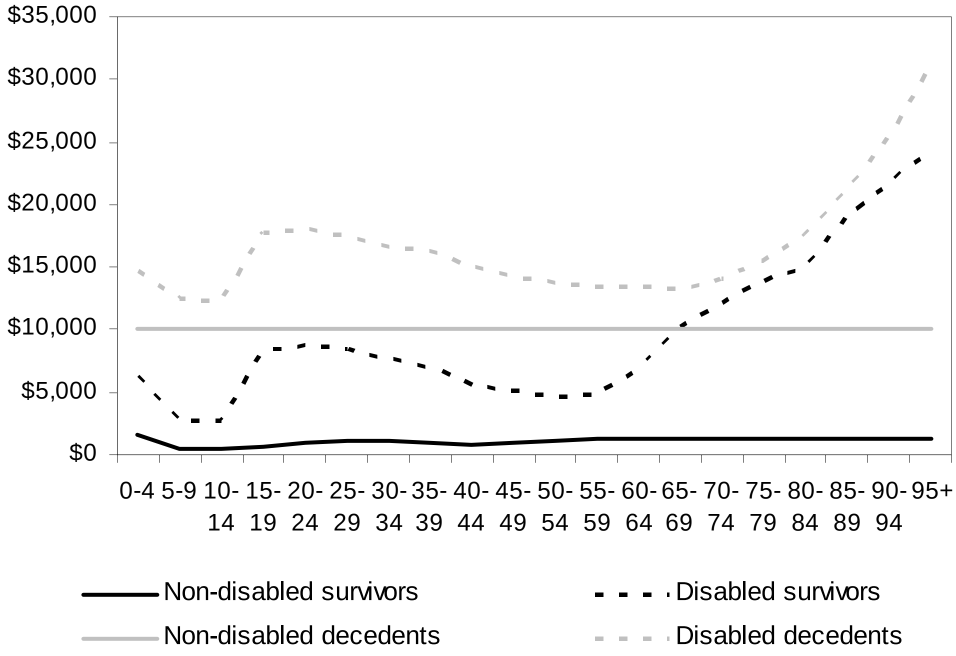
The Ministry of Health database provides estimates of expenditure by age, sex, and service group. The same service groups are used in Treasury's Long-Term Fiscal Model. Lacking direct measures, we used these data to construct indirect estimates of expenditure by age, sex, and our four health statuses (disabled decedent, non-disabled decedent, disabled survivor, non-disabled survivor.) Table 7 summarizes our assumptions on how expenditures were distributed.

Table 7 – Assumptions about distribution of expenditure within each age-sex group in 2001/02

Service group	Expenditure by health status
Public health	Per capita expenditure equal for all health statuses
Disability support services	No expenditure on non-disabled survivors and non-disabled decedents; per capita expenditure equal for disabled survivors and disabled decedents
Mental health	As for disability support services.
Personal health	Per capita expenditure for non-disabled and disabled decedents fixed at $10,000, based on overseas data and limited New Zealand data on costs and distance to death. At ages 0-54, per capita expenditures equal for disabled and non-disabled survivors. At ages 55 and over, per capita expenditure of non-disabled survivors equal to that of non-disabled survivors aged 50-54. Per capita expenditure for disabled survivors calculated as a residual.

The resulting costs per capita are summarized in Figure 4. Given that these estimates are, unavoidably, tentative, we carry out sensitivity tests based on alternative estimates. We construct these alternative estimates by altering the assumption about the "cost of dying", which in Figure 4 is $10,000.

Figure 4 - Expenditure per capita by health status in 2001/02 (males and females combined)



Note – Strictly speaking, the graphs shows expenditure per person-year lived.

6 Results

6.1 Trends in age structure and health

We look briefly at trends in age structure and health. Table 8 shows estimates and projections for life expectancy. The projections are based on the assumption that, across both sexes and all ages, mortality rates decline at 1.5% per year, which is approximately the historical average (see Section 5.1.1). Under this assumption, life expectancy increases to 86.3 years by 2051. The projected extension in life expectancy between 2002 and 2051 turns out to exactly equal the actual extension in life expectancy between 1951 and 2002, at 8.6 years. Statistics New Zealand, like most official statistical agencies, assumes that gains in life expectancy will slow in the coming decade: their projected life expectancy for 2051 is only 84.5 years[7]. A growing number of academic demographers, however, question the assumption that gains in life expectancy will slow (Oeppen and Vaupel 2002). Sensitivity tests, not shown here, indicate that if mortality rates were to decline at 1.0% per year, life expectancy in 2051 would be 83.8 years. Conversely, if rates were decline at 2.0% per year, life expectancy in 2051 would be 88.9 years.

[7] This is the 'median' assumption, from the 2001-base projections, available at www.stats.govt.nz.

Table 8 – Estimates and projections of life expectancy (male and female combined)

	1951	2002	2026	2051
Life expectancy (years)	69.1	77.7	82.3	86.3

Note – Calculations assume that mortality rates decline at 1.5% per year after 2002.

Increases in life expectancy, combined with the ageing of the baby boom cohorts, lead to substantial increases in the population share of older age groups, as indicated by Table 9. Under the assumptions used, the population share of disabled people and decedents (ie people in their last year of life) increases much less dramatically. The finding that the population shares of the aged rise more quickly than the population shares of people with disabilities and decedents is preserved under quite different assumptions about disability and mortality rates. For instance, even if disability rates by age and sex are were to remain constant, the population share of people with disabilities would only rise to 18% in 2051.

Table 9 – Estimates and projections of population share of selected age groups and health statuses

	Estimate			Projection	
Percent of population	1951	1976	2002	2026	2051
Age 65 and over	9.0%	8.8%	11.9%	17.9%	24.1%
Age 85 and over	0.3%	0.6%	1.3%	2.4%	5.5%
Disabled	10.1%	10.2%	12.0%	12.6%	13.1%
Decedents	0.9%	0.8%	0.7%	0.8%	1.0%

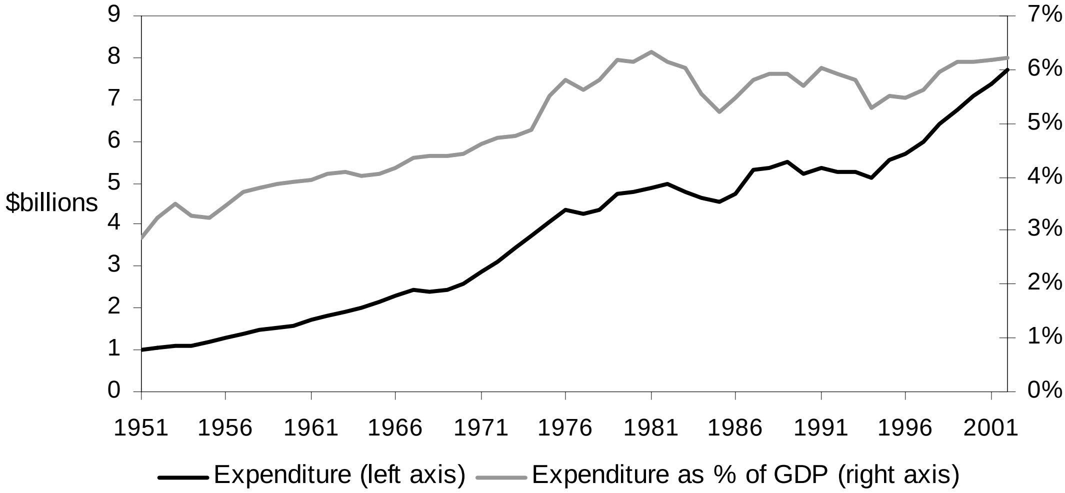
Notes – Calculations assume that disability rates constant until 2002, and begin declining at 0.5% per year from that time. Mortality rates are assumed decline at 1.5% per year after 2002.

6.2 Historical expenditure growth and its components

6.2.1 Total expenditure

Figure 5 shows government expenditure on health, expressed in 2001/02 dollars. As far as possible, the expenditure series is based on the same set of services as was provided through Vote Health in 2001/02. This means, for instance, that the series includes Disability Support Services throughout the 1990s, even though DSS was funded through the Ministry of Social Welfare in the early 1990s and funded through the Ministry of Health in the late 1990s.

Figure 5 – Government health expenditure, in 2001/02 dollars, and as a percent of GDP



Source – Expenditure and GDP data from Treasury

As can be seen in Figure 5, government expenditure on health has grown from about one billion dollars in 1950/51 to over seven billion dollars in 2001/02. Growth rates have fluctuated markedly: expenditures grew very slowly from the mid-1970s to the mid-1990s, for instance, but have grown much more quickly since then. Much of the slow growth in the 1980s coincided with periods of high inflation, when nominal expenditure was increasing even as real expenditure fell.

As explained in Section 4.2, our model can be applied to the historical expenditure series, to show what proportion of observed growth was attributable to population change and what was attributable to other causes:

Growth rate for expenditure	=	Growth rate for population size	+	Growth rate for ageing and health effect	+	Growth rate for coverage and price effect		(3)

Here, and in the rest of this paper, all expenditures are real. The "ageing and health effect" measures expenditure increases necessary to offset unfavourable trends in age structure and health. The "coverage and price effect" is a residual term, capturing expenditure growth that is not attributable to population growth or to ageing and health trends. It includes such things as the introduction of new technologies, the expansion in the range of conditions treated, and rising wages for health workers.

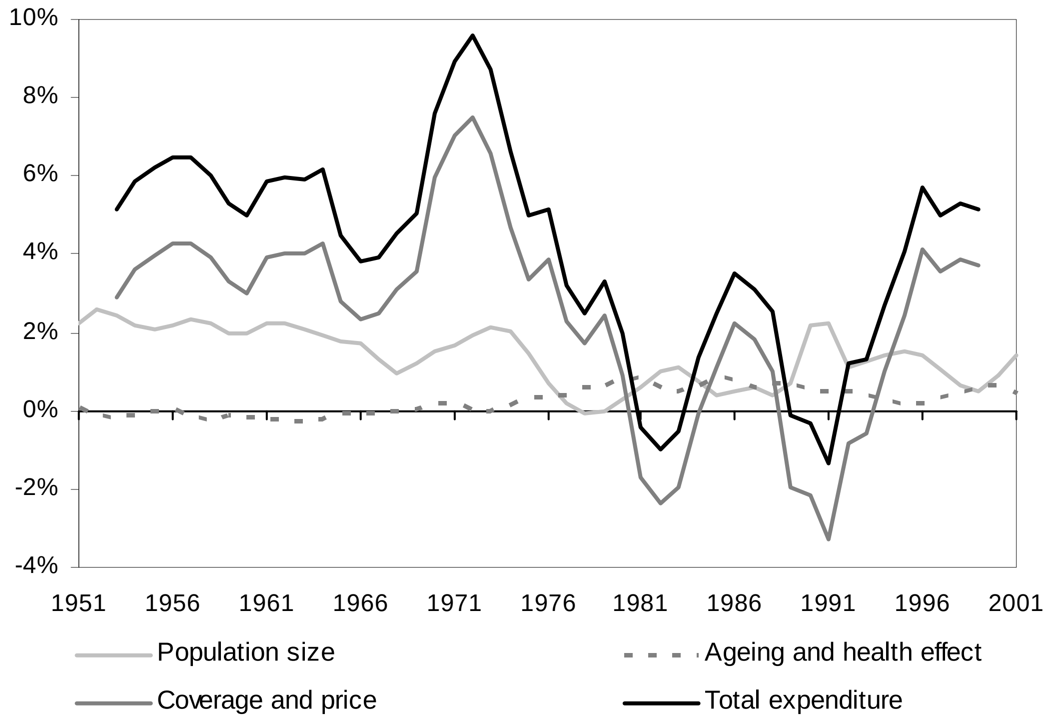
Table 10 – Average growth rates for total government health expenditure and its components, 1951-2002

Average growth rates	1951-1961	1961-1971	1971-1981	1981-1991	1991-2002	1951-2002
Population size	2.20%	1.68%	1.03%	0.82%	1.34%	1.39%
Ageing and health effect	-0.10%	-0.09%	0.35%	0.68%	0.45%	0.25%
Coverage and price	3.31%	3.45%	3.99%	-0.60%	1.85%	2.35%
Expenditure	5.40%	5.04%	5.37%	0.90%	3.64%	3.99%

Note – Calculations assume that disability rates constant from 1951 to 2002.

Table 10 shows the results from applying this analysis to historical data for New Zealand. The numbers for "expenditure" and "population size" are calculated directly from the total expenditure and total population series. The results for the ageing and health effect are calculated using the model and the data, and assumptions on age structure and health. "Coverage and price" is calculated by subtracting the growth rates for population size and the ageing and health effect from the growth rates for expenditure. Figure 6 plots the data summarized in Table 10.

Figure 6 – Annual growth rates for government health expenditure and its components 1951-2002



Note – The results for coverage and price and total expenditure are 5-year moving averages.

During the period 1951-2002, the ageing and health effect made a relatively small contribution to overall growth in health expenditure. Population growth made a more substantial contribution. However, the dominant factor was clearly growth in coverage and price.

We experimented with various alternative specifications for expenditure in different health statuses and for disability decline. The main substantive result was, however, unchanged. Coverage and price consistently emerged as the most important component of expenditure growth, population growth the second most important, and ageing and health the least important.

During the 1950s and 1960s, spending grew extremely rapidly, though demographic conditions were, if anything, reducing the need for spending. Real per capita spending actually fell several times during the 1980s and early 1990s, just as demographic change started to absorb extra expenditure. Spending has risen quickly since the early 1990s, well in excess of what would be predicted from demographic trends.

6.2.2 Government health expenditure as a percent of GDP

As Figure 5 shows, expenditure as a percent of GDP rose steadily from the 1950s to about 1980, but since then has shown no consistent trend upwards or downwards. The sharp fluctuations in growth rates mean that conclusions about historical trends in expenditure are extremely sensitive to the choice of period. If the whole period 1950/51-2001/02, or the period since the early 1990s, is used, then expenditure as a percent of GDP appears to have been increasing steadily. If the period since the late 1970s is used, then expenditure as a percent of GDP appears to be roughly stable (see also Table 11).

As with growth in expenditure, growth in government expenditure as a percent of GDP can be expressed in terms of three underlying components:

$$\begin{array}{c}\text{Growth rate for}\\ \text{expenditure as \% of GDP}\end{array} = \begin{array}{c}\text{Growth rate for ageing}\\ \text{and health effect}\end{array} + \begin{array}{c}\text{Growth rate for}\\ \text{coverage and price}\end{array} - \begin{array}{c}\text{Growth rate for}\\ \text{GDP per capita}\end{array} \quad (4)$$

Note that Equation 4, unlike Equation 3, does not include a term for population size. Population size raises both expenditures and GDP, so its effects cancel out. Equation 4 includes the growth rate of GDP per capita, which is subtracted from the other two terms. All else equal, faster GDP growth implies slower growth in expenditure as a percent of GDP.

Table 11 shows results from applying Equation 4 to New Zealand data. The growth rates for expenditure as a percent of GDP and for GDP per capita are calculated from standard GDP data. As with Table 10, the growth rate for the ageing and health effect is calculated using the model. The growth rate for coverage and price is calculated from the other terms, using Equation 4.

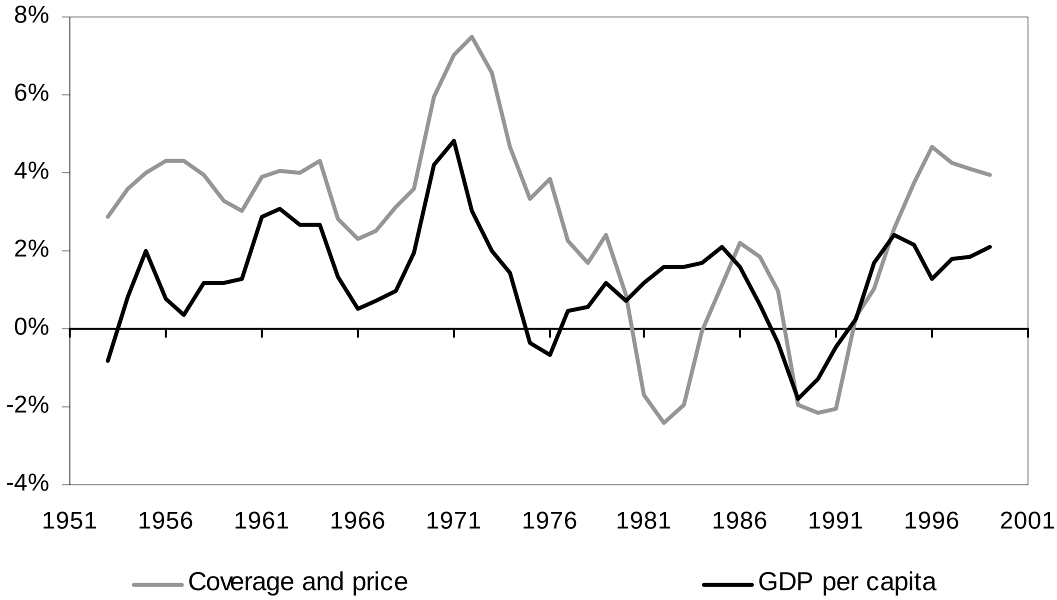
Table 11 – Average growth rates for government health expenditure as a percentage of GDP, and its components, 1951-2002

Average growth rates	1951-1961	1961-1971	1971-1981	1981-1991	1991-2002	1951-2002
Ageing and health effect	-0.10%	-0.09%	0.35%	0.68%	0.45%	0.25%
Coverage and price	3.31%	3.45%	3.99%	-0.60%	1.85%	2.35%
GDP per capita	0.09%	1.76%	1.20%	0.57%	1.97%	1.10%
Expenditure as % of GDP	3.11%	1.59%	3.14%	-0.48%	0.33%	1.51%

Notes – Calculations assume that disability rates constant from 1951 to 2002.

The results in Table 11 suggest that there might be a positive relationship between growth in the coverage and price effect and growth in GDP per capita: the coverage and price effect seems to grow fastest in periods when the economy is doing well. The more detailed results shown in Figure 7 largely bear this out except for a period in the early 1980s. This period in New Zealand was characterised by high inflation, large government budget deficits and subsequent economic reforms.

Figure 7 – Growth rates for the coverage and price effect and GDP per capita



Note – both series are 5-year moving averages, centred on the year shown. Calculations assume disability rates constant from 1951 to 2002.

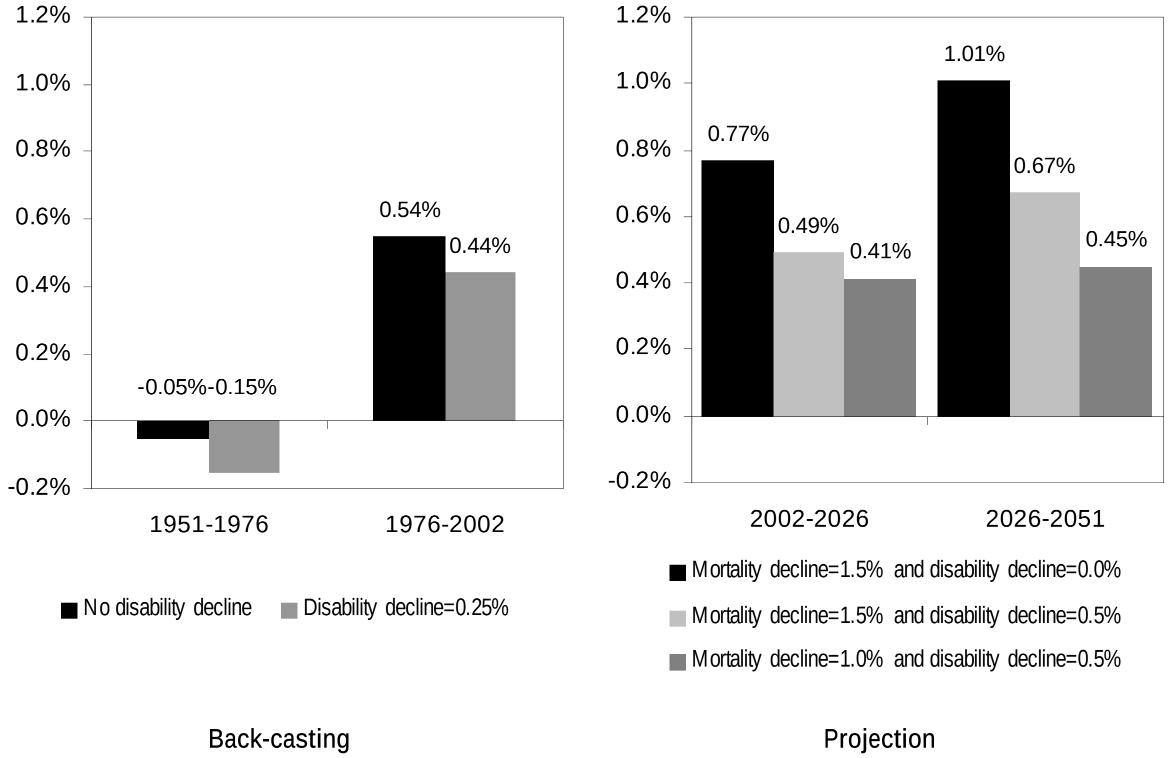
6.3 Comparison of past and projected spending pressures attributable to ageing and health

The population share of older people will rise more quickly over coming decades than it has in the recent past. (Table 9 presents some representative statistics). Many commentators argue that the New Zealand health system therefore faces rapidly increasing spending pressures. There are, however, potentially important offsetting effects: declines in disability and mortality rates would reduce the proportion of each age group that is disabled or in the last year of life. It is therefore not obvious how future spending pressures attributable to ageing and health will compare to past spending pressures.

Spending pressures attributable to ageing and health are measured in our model by the "ageing and health effect". Changes in spending pressures can be summarized by the growth rate of this effect. Estimates of historical and projected growth rates are presented in Figure 8.

The left panel presents two sets of results from the back-casting. The first set is based on our benchmark assumption that age-specific disability rates were constant over the period; the second is based on the assumption that disability rates declined at 0.25% per year. The growth rate of the ageing and health effect is lower under the second assumption. Under both assumptions, however, the growth rate increases considerably between the 1951-1976 and the 1976-2002 period.

Figure 8 – Annual average growth rate for ageing and health effect



The right panel presents three sets of projections' results. The first is based on an assumption of 1.5% annual decline in mortality rates but no decline in disability rates. The second is based on our benchmark assumption of 1.5% mortality decline and 0.5% disability decline, and the third on an assumption of only 1.0% mortality decline and the original 0.5% disability decline. Under the first, constant-disability, scenario, the growth in the ageing and health effect increases over coming decades, consistent with conventional expectations. Under the second and third scenarios, however, growth in the ageing and health effect in 2002-2026 is roughly the same as growth in 1976-2002, and only slightly higher in 2026-2051. This demonstrates the potential for decline in disability rates to offset the effects of changes in age structure.

We also carried out projections and back-casting using different assumptions about the relative costs of disabled, non-disabled, decedents, and survivors. The effects of these variations were small, and are not shown here.

6.4 Comparison of results from different versions of the model

In Section 3.2 we distinguished between health expenditure models that incorporate cost differences by age and sex alone, and models that also incorporate differences by health status. Johnston and Teasdale (1999) and Treasury's Long-Term Fiscal Model[8] are examples of the former; Cutler and Sheiner (1998) and our model are examples of the latter.

Table 12 – Differences in the "ageing and health" effect under the "basic" and "full" versions of the model

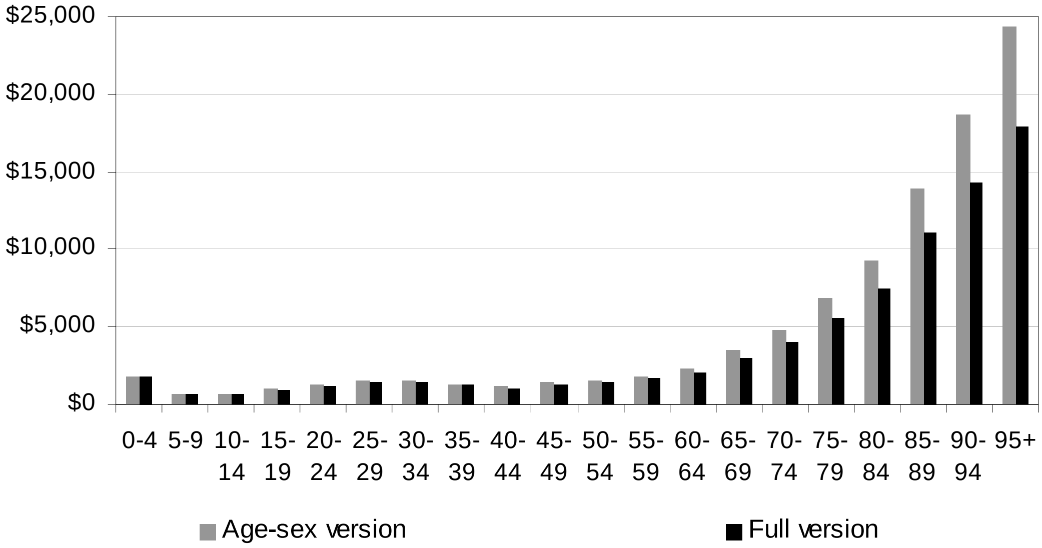
	Assumptions used to generate scenario		Ageing and health effect in 2051 (=100 in 2002)		
Scenario	Mortality decline	Disability decline	(a) Age-sex version	(b) Full version	Percent difference (=*a*/*b*-1)
1	1.5%	0.5%	154	131	18.0%
2	1.0%	0.5%	143	123	16.6%
3	1.5%	0.0%	154	152	1.3%

We have constructed an "age-sex" version of our model that uses only age and sex, and ignores disability and distance to death (see Section 4.5). Table 12 compares results from this version and the full model. The indicator used in Table 12 is the ageing and health effect in 2051, with the effect normalized to 100 in 2002. The right-most column of the table shows the percentage difference between the projected ageing and health effects. Because the different versions of the model use the same numbers for population size, and for coverage and price, any projected values for expenditures will differ only to the extent that results for the ageing and health effect differ. If, for instance, the age-sex version of the model yields a value for the ageing and health effect that is 10% higher than the full version, then the age-sex version will also yield a value for total expenditure that is 10% higher.

Scenario 1 in Table 12 is our benchmark case of 1.5% annual decline in mortality rates, and 0.5% annual decline in disability rates. Under this scenario the age-sex model produces an ageing and health effect that is 18% higher than the full model. Figure 9 helps explain why. It shows health expenditure in 2051 under the age-sex and full versions of the model, using the same mortality and disability assumptions as Scenario 1. (Coverage and price is not important to the comparison, so its growth rate has been set to zero.) The age-sex model, which ignores the assumed changes in disability and distance to death, projects per capita expenditures for older age groups that are substantially higher than the full model.

[8] The latest version of the Long-Term Fiscal Model can be downloaded from http://www.treasury.govt.nz/ltfm/default.asp.

Figure 9 – Health expenditure per capita in 2051, under the age-sex and full versions of the model



Note – These results assume that, after 2002, mortality rates decline at 1.5% per year, disability rates decline at 0.5% per year, and the coverage and price effect is constant.

As the second scenario of Table 12 shows, the gap between the age-sex and full models is not greatly affected by changes in the assumption about mortality decline. The third scenario shows, however, that the divergence is strongly conditional on assumptions about disability: if disability rates are assumed to remain constant, then the basic and full versions of the model give virtually the same results.

To identify more clearly the reason why the age-sex and full versions of the model give different results, we have set up two '"intermediate" versions. The first, the "distance-to-death" version, incorporates age, sex, and distance to death, but not disability; the second, the "disability" version, incorporates age, sex, and disability, but not distance to death (see Section 4.5 for details.) Experimentation with the different versions shows that, when disability rates are assumed to decline, the distance to death version gives results close to the age-sex version, while the disability version gives results close to the full version. When disability rates are assumed to remain constant, all four versions of the model give similar results. Varying the mortality rate affects all models by approximately the same amount. The apparent implication is that disability has a potentially large influence on expenditures, while distance-to-death effects do not.

6.5 Distribution of expenditure by age

Older people, on average, have much poorer health than younger people. There is therefore much greater potential for health improvements to offset pressures for growth in per capita spending on old people. This difference is captured in our model. Under the standard assumption of 0.5% annual decline in disability rates, the proportional increase in per capita spending is substantially lower for older people than it is for younger people. Table 13 shows some representative numbers.

Table 13 – Expenditures per capita, for selected ages groups, 2002 and 2051

Age group	2002	2051	% increase
0-4	1,816	3,687	103%
30-34	1,532	2,916	90%
60-64	2,354	4,351	85%
90-94	18,718	30,274	62%

Notes – Calculations assume that disability rates decline at 0.5% per year, mortality rates are decline at 1.5% per year, and coverange and price increases at 1.5% per year.

Even with the slower per capita growth, however, the share of total health expenditure going towards older people is projected to grow substantially over coming decades. Figure 10 shows results from our benchmark scenario, together with back-casting results for 1950/51. The expenditure share of people aged 65 and over rises from 29% in 1950/51 to 40% in 2001/02 and 63% in 2050/51. The reason why the expenditure share of older people rises is that their population share rises. The reason why the expenditure share of older people is higher than their population share is that, even with slower growth, per capita expenditure on older people remains much higher than per capita expenditure on younger people.

Figure 10 – Distribution of expenditure by broad age group

Note – The calculations are based on the assumption that disability rates decline at 0.5% per annum and mortality rates decline at 1.5% per year from 2002 to 2051.

Alternative assumptions yield slightly different results. For instance, more pessimistic assumptions for disability decline yield slightly greater increases in the share of expenditure going to older people. However, the basic qualitative finding—that the expenditure share of old people rises substantially—is robust to many different specifications of health trends.

6.6 Future trends in health expenditures

Models such as ours can, in principle, generate projections of future expenditure levels. Supplied with plausible assumptions about demographic trends, health trends, productivity growth, and cost growth, the model produces numbers for future health expenditure. We are, however, reluctant to generate these projections.

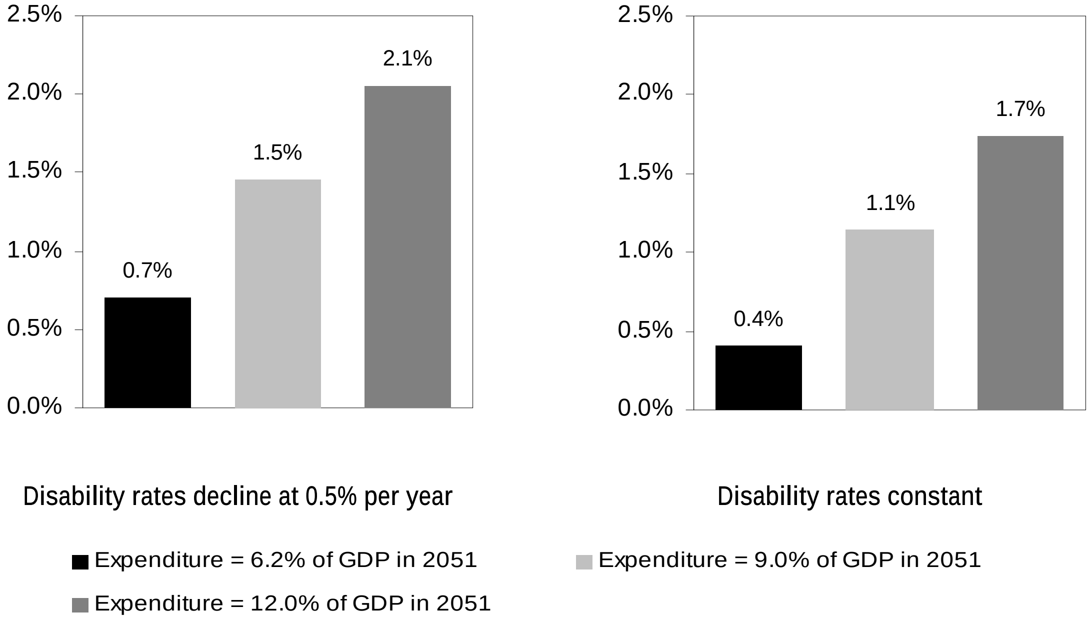
One reason for this reluctance is the difficulty of choosing values for the coverage and price term. As Section 6.2 demonstrates, coverage and price was the main determinant of health expenditure growth in the past. The results in Section 6.3 suggest that the ageing and health effect will contribute more to future expenditure growth than it has to past growth. But coverage and price will nevertheless continue to be important. This means that obtaining sensible predictions for overall expenditures is only possible if coverage and price can be modelled satisfactorily. The main objective of our research, however, has been to understand the contribution of population ageing to health expenditure growth, and we have simply treated coverage and price as an undifferentiated "everything else" term. Our model is designed for making predictions about extra increments in health expenditures attributable to population ageing, such as those in Section 6.3. It is not designed for making predictions about overall expenditures.

Moreover, even if we had a more sophisticated model of coverage and price, the standard methods for projecting government health expenditures would still be problematic, at least for government health expenditure in New Zealand. The standard methods essentially treat overall expenditure as an outcome, and trends in demography and coverage and price as determinants of this outcome. This may be appropriate for forecasting expenditure in health systems like private health care in the United States, where there is no overall expenditure cap, and where trends in coverage and price emerge from large numbers of decisions by large numbers of actors. But it is perhaps not appropriate for forecasting expenditure by the public health system in New Zealand, where the government has final say on overall expenditure levels. In this case, it is probably more accurate to treat coverage and price as an outcome, and overall expenditure as a determinant.

This, in any case, is what Figure 11 does. Rather than answering the traditional question "What level of health expenditure would be implied by a given growth rate for coverage and price?", it answers the question "What growth rate for coverage and price would be consistent with a given level of health expenditure?"

In constructing Figure 11, we needed to choose values for health expenditure as a percent of GDP in 2050/51. We started by setting expenditure as a percent of GDP in 2050/51 equal to its level in 2001/02, at 6.2%. To obtain a "large" value for expenditure, we doubled 6.2% and rounded, yielding 12.0%. We chose 9.0% as an intermediate value. The choice of values was obviously somewhat arbitrary, and we have made no attempt to rank them by probability or desirability.

Figure 11 – Growth rates for the coverage and price effect consistent with selected values for expenditure as a percent of GDP in 2050/51



Note – In both cases, mortality rates are assumed to decline at 1.5% per year, and GDP per employee is assumed to grow at 1.5% per year.

In our model, the relationship between expenditure levels and coverage and price depends on assumptions about mortality, disability, and GDP per employee. Figure 11 presents results from two sets of assumptions. Both assume that mortality rates decline at 1.5% per year and GDP per employee grows at 1.5% a year. The results shown in the left panel assume that disability rates decline at 0.5% per year; the results in the right panel assume constant disability rates. The implied growth rates for coverage and price range from 2.1% per year (for the case where health expenditure reaches 12.0% of GDP and disability rates decline) to 0.4% (where health expenditure stays at 6.2% and disability rates are constant).

The right-hand panel shows results from a sensitivity test in which age-specific disability rates are assumed to remain constant. The associated growth rates for coverage and price are all lower than the benchmark case by about 0.4 percentage points. We conducted another sensitivity test using a growth rate for GDP per employee of 1.0% per year rather than 1.5%. The results are not shown here, but are close to those in the right-hand panel.

7 Summary and conclusions

The New Zealand population will age substantially over coming decades. Older people consume more health resources than young people, so population ageing is likely to exert upward pressure on government health expenditure. Evidence from New Zealand and overseas suggests, however, that the main determinant of health service use is not age but health, and that the reason why older people consume more resources is their poorer health. Investigations of future health expenditure can therefore profit from looking at health status as well as age structure.

International research on health expenditures generally uses two measures of health status. The first is disability rates and the second is “distance to death”, or the proportion of people in their last year of life. We construct projections of both these measures, linked to our projections of age structure. Based on a systematic review of the international evidence, we argue that disability rates within each age group are likely to decline, though we also experiment with specifications in which age-specific disability rates are held constant.

When combined with estimates of cost by age, sex, and health status, these projections can be used to model spending pressures due to population ageing. In this paper we refer to such pressures as the “ageing and health” effect. Because New Zealand, unlike some other developed countries, lacks good data on costs by health status, we have had to estimate these costs indirectly. This is an important limitation of our study. We do, however, investigate whether our findings our sensitive to alternative specifications of costs.

We use the model to examine how government health expenditures are distributed among different age groups. Under our benchmark assumptions, the share of people aged 15-64 falls from 52% in 1950/51 to about 31% in 2050/51, while the share of people aged 65 and over rises from 29% to 63%. This shift in expenditure shares occurs despite the fact that, under our benchmark assumptions, expenditure per old person grows less quickly than expenditure per young person. The reason expenditure per old person grows more slowly than expenditure per young person is that there is more scope for offsetting spending pressures through lowering disability among the elderly, since the disability rates of elderly people are relatively high. If these disability reductions did not take place, then the expenditure share of older people would increase further.

The model’s results on expenditure by age, and hence expenditure shares, are driven mainly by changes in health status. Health status is, however, only one of the factors determining expenditure by age. Other factors include technology, expectations, and social priorities. The model’s results do, however, suggest that there will be an increasing disjunction between those who pay for government health services—mainly the working-age population—and those who receive them – mainly older people.

Assuming moderate declines in age-specific disability rates, spending pressures attributable to the ageing and health effect will grow over the next 25 years, but perhaps no more quickly than they have grown over the past 25 years. In other words, the annual proportional increases in government health spending required to accommodate changes in age structure and health may be no larger up to the mid-2020s than they have been since the 1970s. Spending pressures are likely to grow more quickly after the mid-2020s. Spending pressures will also be higher if disability rates do not decline. The results do, nevertheless, suggest that population ageing may not necessitate large increases in the growth rate of government health expenditure.

Experiments with our model suggest that falling disability rates do more to offset spending pressures than distance-to-death effects. This is plausible, since people in their last year of life never make up more than one percent of the total population, and account for a relatively small fraction of costs, whereas people with disabilities currently make up about 12 per cent of the population. Some overseas studies have found distance-to-death effects to be important, but these studies have looked at elderly populations, which have a disproportionately high number of people in the last year of life (Miller 2001, Spillman and Lubitz 2000). We are, however, unable to estimate distance-to-death effects precisely, given the weakness of the underlying cost data. Regardless of the exact contributions of disability and distance to death, it seems likely that trends in age structure and health status will do less to raise the growth rate for government health expenditures than is sometimes assumed.

We have analysed historical expenditure growth to examine the relative contributions of age structure and health and of the remaining factors, which we group together under the term “coverage and price”. Coverage and price includes things such as technological change, conditions treated, and input prices including wages. A high growth rate for coverage and price means that substantial new resources are flowing into government health services, net of what is required to offset demographic changes. These new resources may be committed to better or expanded treatments that improve population health, or they may simply be absorbed in price rises; we make no attempt to differentiate between the two situations.

The analysis of historical trends shows that, between 1950/51 and 2001/02, growth in coverage and price was the main source of long-run growth in government health expenditure. It was also the main cause of fluctuations in the growth rate. During the 1950s and 1960s, government health expenditure grew extremely rapidly, though demographic conditions were, if anything, reducing the need for spending. Real per capita expenditure actually fell several times during the 1980s and early 1990s, just as demographic change started to absorb extra expenditure. Spending has increased quickly since the early 1990s, because growth in coverage and price has risen to 3-4% per year.

If coverage and price has been the decisive factor in the past, it is also likely to be decisive in the future. Varying assumptions about coverage and price within plausible bounds has a much greater effect on eventual levels of health expenditure than varying assumptions about disability. The earlier Ministry of Health study, and overseas studies, reached similar conclusions (Cutler and Sheiner 1998, Jacobzone *et al* 2000, Johnston and Teasdale 1999, Miller 2001). Creedy and Scobie (2002) report similar findings for other social expenditures such as pensions.

This raises the question of how much growth in coverage and price New Zealand can afford. The answer depends, of course, on the definition of affordable. We investigate the consequences of three possible definitions. The first is that government health expenditure is held to 6.2% of GDP in 2050/51, which is the same percentage as 2001/02. The second is that government health expenditure is reaches 9.0% of GDP in 2050/51, and the third is that it reaches 12.0% of GDP in 2050/51, or somewhat less than twice current levels. Under our benchmark assumptions for disability, mortality, and labour productivity, the targets of 6.2%, 9.0%, and 12.0% are consistent with annual growth rates for coverage and price of 0.7%, 1.5%, and 2.1%. Whether values of 0.7%, 1.5%, and 2.1% are considered low or high by historical standards depends on the historical period chosen. However, all are low compared with 3-4% annual growth in coverage and price since the mid-1990s. The implication is that recent growth rates could not be sustained indefinitely if the long-term goal of constraining expenditure to 6-12% of GDP were to be adopted.

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Appendix 1 – Data on expenditure, distance to death, and disability in 2001

Appendix Table 1 – Health expenditure, distance from death, and disability by age and sex

	Annual per capita health expenditure		Percent of population in last year of life		Percent of population with disability	
Age group	Male	Female	Male	Female	Male	Female
0-4	1,877	1,623	0.16%	0.13%	3.7%	2.7%
5-9	723	624	0.02%	0.02%	9.2%	5.8%
10-14	658	585	0.03%	0.02%	9.2%	6.1%
15-19	843	1,111	0.09%	0.04%	5.4%	4.2%
20-24	881	1,638	0.13%	0.04%	4.6%	4.7%
25-29	930	2,022	0.13%	0.05%	5.1%	6.1%
30-34	905	2,005	0.14%	0.05%	5.8%	7.3%
35-39	937	1,646	0.14%	0.07%	6.5%	8.2%
40-44	986	1,262	0.19%	0.12%	8.2%	9.5%
45-49	1,218	1,403	0.27%	0.20%	10.9%	10.8%
50-54	1,442	1,551	0.43%	0.32%	13.6%	11.5%
55-59	1,772	1,773	0.74%	0.51%	16.8%	12.8%
60-64	2,349	2,199	1.19%	0.82%	20.8%	16.0%
65-69	3,519	3,123	2.10%	1.27%	25.5%	22.2%
70-74	4,903	4,219	3.42%	1.95%	32.1%	31.2%
75-79	6,840	6,303	5.58%	3.29%	42.8%	43.0%
80-84	8,976	8,985	9.18%	5.98%	59.0%	56.3%
85-89	12,978	13,735	15.24%	10.77%	77.6%	67.0%
90-94	15,573	18,944	25.87%	18.97%	91.2%	78.3%
95+	18,738	24,738	30.61%	29.47%	97.5%	89.8%

Sources – The estimates from health expenditure are from the Ministry of Health, and the estimates of disability rates are calculated from the 2001 Post-Censal Disability Survey.

Appendix 2 – Further details on the model

Notation used in the model

Note – the absence of a time index implies that a variable is constant over time.

Symbol	Definition
$a(t)$	The growth rate of output per employee $v(t)$
b	Rate of decline for age-sex-specific mortality rates
$c_{ij}(t)$	Cost per person-year lived for people in age group *i* and sex *j*
$c_{ij}^{d}(t)$	Cost per person-year lived for decedents in age group *i* and sex *j*
$c_{ij}^{s}(t)$	Cost per person-year lived for survivors in age group *i* and sex *j*
$c_{ij}^{u}(t)$	Cost per person-year lived for disabled people in age group *i* and sex *j*
$c_{ij}^{w}(t)$	Cost per person-year lived for non-disabled people in age group *i* and sex *j*
$c_{ij}^{du}(t)$	Cost per person-year lived for disabled decedents in age group *i* and sex *j*
$c_{ij}^{dw}(t)$	Cost per person-year lived for non-disabled decedents in age group *i* and sex *j*
$c_{ij}^{su}(t)$	Cost per person-year lived for disabled survivors in age group *i* and sex *j*
$c_{ij}^{sw}(t)$	Cost per person-year lived for non-disabled survivors in age group *i* and sex *j*
$c_{k}(t)$	The health costs per person-year lived of people in group *k*
$E(t)$	Total expenditures
$g(t)$	The growth rate for the cost per person-year lived
$m_{ij}(t)$	The mortality rate for people in age group i and sex j (used when it is clear from the context whether the actual or model rates are meant)
$m_{ij}^{actual}(t)$	The actual historical mortality rate for people in age group i and sex j
$m_{ij}^{model}(t)$	The mortality rate for people in age group i and sex j predicted by the model
$NT(t)$	Net transfers
$P_{ij}(t)$	Person-years lived by people in age group *i* and sex *j*
$P_{ij}^{d}(t)$	Person-years lived by decedents in age group *i* and sex *j*
$P_{ij}^{s}(t)$	Person-years lived by decedents in age group *i* and sex *j*
$P_{ij}^{w}(t)$	Person-years lived by non-disabled people in age group *i* and sex *j*
$P_{ij}^{u}(t)$	Person-years lived by disabled people in age group *i* and sex *j*
$P_{ij}^{du}(t)$	Person-years lived by disabled decedents in age group *i* and sex *j*
$P_{ij}^{dw}(t)$	Person-years lived by non-disabled decedents in age group *i* and sex *j*
$P_{ij}^{su}(t)$	Person-years lived by disabled survivors in age group *i* and sex *j*

$P_{ij}^{sw}(t)$	Person-years lived by non-disabled survivors in age group *i* and sex *j*
$P_k(t)$	Person-years lived by people in group *k*
t_0	The launch year for the projections
$u_{ij}(t)$	Prevalence of disability in age group *i* and sex *j*
$v(t)$	GDP per employee
$VH(t)$	Actual Vote Health expenditure
$VH^{93}(t)$	Expenditure on the basket of services funded under Vote Health in 1992/93
$VH^{02}(t)$	Expenditure on the basket of services funded under Vote Health in 2001/02
w_{ij}	The proportion of people sex i and age group j who are employed
$Y(t)$	GDP
z_{ij}	The proportion of deaths in age group *i* and sex *j* that the 2001 cause-of-death statistics attribute to "injury".

Previous simulation models

Calculation of GDP

In most long-term expenditure projections, including ours, GDP is calculated using the equation

$$Y(t) = \sum_i \sum_j P_{ij}(t) w_{ij}(t) v(t), \tag{5}$$

where $Y(t)$ is GDP, w_{ij} is the proportion of people in age group i and sex j who are employed, and $v(t)$ is average GDP per employee (ie labour productivity). Average GDP per employee $v(t)$ is assumed to grow at a constant rate a, so that

$$Y(t) = \sum_i \sum_j P_{ij}(t) w_{ij} v_{ij}(t_0)[1+a]^{t-t_0}, \; t \geq t_0. \tag{6}$$

Demonstration that the Johnston and Teasdale model has the same structure as Table 2

A more general form of the model presented in Table 2 is

$$E(t) = \sum_k c_k(t) P_k(t) , \tag{7}$$

where $E(t)$ is total expenditure, $P_k(t)$ is person years lived by people in group k, and $c_k(t)$ is costs per person-year lived. (Less precisely, $P_k(t)$ is population and $c_k(t)$ is per capita costs.) Examples of relevant groups include the highly aggregate categories "young" and "old" shown in Table 2, conventional demographic categories such as females aged 10-14, or categories combining demographic and health status, such as disabled females aged 10-14.

Some algebraic manipulation may be necessary to demonstrate that a particular model is an instance of Equation 7. We illustrate using the model set out in Johnston and Teasdale (1999).

In Johnston's and Teasdale's (1999: 11) model, expenditure in year t equals expenditure in year $t-1$ multiplied by three things: (i) an adjustment for population size, $P(t)/P(t-1)$; (ii) an adjustment for ageing effects (Johnston and Teasdale 1999: 9)

$$\frac{\sum_k P_k(t)c_k(t-1)}{\sum_k P_k(t-1)c_k(t-1)}\frac{P(t-1)}{P(t)}; \tag{8}$$

and (iii) an adjustment for rising costs, $1+g$.

Combined, this gives:

$$E(t)=E(t-1)\frac{P(t)}{P(t-1)}\frac{\sum_k P_k(t)c_k(t-1)}{\sum_k P_k(t-1)c_k(t-1)}\frac{P(t-1)}{P(t)}[1+g] \tag{9}$$

Cancelling, and using the fact that $c_k(t)=c_k(t-1)[1+g]$, gives

$$E(t)=E(t-1)\frac{\sum_k P_k(t)c_k(t)}{\sum_k P_k(t-1)c_k(t-1)}. \tag{10}$$

Since

$$E(t-1)=\sum_k P_k(t-1)c_k(t-1), \tag{11}$$

Equation 10 reduces to Equation 6, as required.

The structure of the model

The demographic-health sub-model

Person-years lived during year t are classified by 5-year age group (indexed by i) and by sex (indexed by j). Within each age-sex-group, person-years are further subdivided by health status, as shown in Appendix Table 2.

Appendix Table 2 – Person-years lived by people of age group i and sex j, by health status

	Non-disabled	Disabled	Total
Survivor	$P_{ij}^{sw}(t)$	$P_{ij}^{su}(t)$	$P_{ij}^{s}(t)$
Decedent	$P_{ij}^{dw}(t)$	$P_{ij}^{du}(t)$	$P_{ij}^{d}(t)$
Total	$P_{ij}^{w}(t)$	$P_{ij}^{u}(t)$	$P_{ij}(t)$

The categories are related as follows:

$$P_{ij}^{s}(t) = P_{ij}^{sw}(t) + P_{ij}^{su}(t)\,, \tag{12}$$

$$P_{ij}^{d}(t) = P_{ij}^{dw}(t) + P_{ij}^{du}(t)\,, \tag{13}$$

$$P_{ij}^{w}(t) = P_{ij}^{sw}(t) + P_{ij}^{dw}(t)\,, \tag{14}$$

$$P_{ij}^{u}(t) = P_{ij}^{su}(t) + P_{ij}^{du}(t)\,, \tag{15}$$

$$P_{ij}(t) = P_{ij}^{s}(t) + P_{ij}^{d}(t) = P_{ij}^{w}(t) + P_{ij}^{u}(t)\,. \tag{16}$$

The expenditure sub-model

The notation for costs per person-year lived is set out in Appendix Table 3.

Appendix Table 3 – Costs per person-year lived for people in age group i and sex j, by health status

	Non-disabled	Disabled	Total
Survivor	$c_{ij}^{sw}(t)$	$c_{ij}^{su}(t)$	$c_{ij}^{s}(t)$
Decedent	$c_{ij}^{dw}(t)$	$c_{ij}^{du}(t)$	$c_{ij}^{d}(t)$
Total	$c_{ij}^{w}(t)$	$c_{ij}^{u}(t)$	$c_{ij}(t)$

The costs per person-year lived are population-weighted averages, and are related to each other as follows:

$$c_{ij}^{s}(t) = \frac{P_{ij}^{sw}(t)}{P_{ij}^{s}(t)} c_{ij}^{sw}(t) + \frac{P_{ij}^{su}(t)}{P_{ij}^{s}(t)} c_{ij}^{su}(t)\,, \tag{17}$$

$$c_{ij}^{d}(t) = \frac{P_{ij}^{dw}(t)}{P_{ij}^{d}(t)} c_{ij}^{dw}(t) + \frac{P_{ij}^{du}(t)}{P_{ij}^{d}(t)} c_{ij}^{du}(t)\,, \tag{18}$$

$$c_{ij}^{w}(t) = \frac{P_{ij}^{sw}(t)}{P_{ij}^{w}(t)} c_{ij}^{sw}(t) + \frac{P_{ij}^{dw}(t)}{P_{ij}^{w}(t)} c_{ij}^{dw}(t)\,, \tag{19}$$

$$c_{ij}^{u}(t) = \frac{P_{ij}^{su}(t)}{P_{ij}^{u}(t)} c_{ij}^{su}(t) + \frac{P_{ij}^{du}(t)}{P_{ij}^{u}(t)} c_{ij}^{du}(t)\,, \tag{20}$$

$$c_{ij}(t) = \frac{P_{ij}^{s}(t)}{P_{ij}(t)} c_{ij}^{s}(t) + \frac{P_{ij}^{d}(t)}{P_{ij}(t)} c_{ij}^{d}(t) = \frac{P_{ij}^{w}(t)}{P_{ij}(t)} c_{ij}^{w}(t) + \frac{P_{ij}^{u}(t)}{P_{ij}(t)} c_{ij}^{u}(t)\,. \tag{21}$$

During any year *t*, all cost weights grow at the same rate, $g(t)$. Let t_0 be the launch year for the projections. When projecting into the future, we use the same value of *g* for all *t*, so that

$$c_{ij}(t) = c_{ij}(t_0)\left[1+g\right]^{t-t_0}, \; t \geq t_0\,. \tag{22}$$

When back-casting, we allow $g(t)$ to vary from year to year. The back-casting equivalent of Equation 22 is

$$c_{ij}(t) = c_{ij}(t_0)\prod_{s=t}^{t_0-1}\frac{1}{1+g(s)},\ t < t_0 \quad . \tag{23}$$

We can now derive Equation 1 in Section 4.2. We present the details only for back-casting, where $t < t_0$, since we only carry out the decompositions on the historical data. The details for projections are very similar.

Let k index all age-sex-groups and all health statuses, and let $P(t) = \sum_k P_k(t)$ be total population. Then

$$E(t) = \sum_k P_k(t)c_k(t) \tag{24}$$

$$= \sum_k P_k(t)c_k(t_0)\prod_{s=t}^{t_0-1}\frac{1}{1+g(s)} \tag{25}$$

$$= P(t)\left[\sum_k \frac{P_k(t)}{P(t)}c_k(t_0)\right]\prod_{s=t}^{t_0-1}\frac{1}{1+g(s)}\ . \tag{26}$$

Equation 26 shows total expenditure as the product of three terms. The first term is simply population size. The second term, $\sum_k \frac{P_k(t)}{P(t)}c_k(t_0)$, is what we call the "ageing and health" effect. The third term, $\prod_{s=t}^{t_0-1}\frac{1}{1+g(s)}$, is the "coverage and price" effect.

Equation 1 can be derived from Equation 26 by applying the general rule that if $X(t) = \prod_i x(t)$, then $\hat{X}(t) = \sum_i \hat{x}_i(t)$, where $\hat{x}(t) \equiv \frac{dx}{dt}\frac{1}{x} = \frac{d\ln x}{dt}$ is the instantaneous rate of change for $x(t)$. (To verify this rule, take logs of $X(t) = \prod_i x_i(t)$ and differentiate.)

Expenditure as a percent of GDP

GDP can be decomposed into three terms, in the same way as total expenditures:

$$Y(t) = P(t)\left[\sum_i\sum_j \frac{P_{ij}(t)}{P(t)}w_{ij}\right]v(t)\ . \tag{27}$$

Here again $P(t)$ is population size. The term $\sum_i\sum_j \frac{P_{ij}(t)}{P(t)}w_{ij}$ measures the proportion of the population that it is employed; it is a "participation effect" analogous to the ageing and health effect. The term $v(t)$ is GDP per employee (ie labour productivity) and is analogous to the coverage and price effect.

As with total expenditures, this can be expressed in terms of growth rates, though in this case it is also necessary to apply the rule that if $X(t) = x_1(t)/x_2(t)$, then $\hat{X}(t) = \hat{x}_1(t) - \hat{x}_2(t)$.

Simpler versions of the model

This section presents the equations underlying the four versions of the model. The equations shown apply to projections; the equations for back-casting are identical apart from the coverage and price term.

The age-sex version:

$$E(t) = \sum_i \sum_j P_{ij}(t) c_{ij}(t_0)[1+g]^{t-t_0}. \tag{28}$$

The disability version:

$$E(t) = \sum_i \sum_j \left[P_{ij}^{w}(t) c_{ij}^{w}(t_0) + P_{ij}^{u}(t) c_{ij}^{u}(t_0) \right][1+g]^{t-t_0}. \tag{29}$$

The distance-to-death version:

$$E(t) = \sum_i \sum_j \left[P_{ij}^{s}(t) c_{ij}^{s}(t_0) + P_{ij}^{d}(t) c_{ij}^{d}(t_0) \right][1+g]^{t-t_0}. \tag{30}$$

The full version:

$$E(t) = \sum_i \sum_j \begin{bmatrix} P_{ij}^{sw}(t) c_{ij}^{sw}(t_0) + P_{ij}^{su}(t) c_{ij}^{su}(t_0) \\ +P_{ij}^{dw}(t) c_{ij}^{dw}(t_0) + P_{ij}^{du}(t) c_{ij}^{du}(t_0) \end{bmatrix} [1+g]^{t-t_0}. \tag{31}$$

Operationalizing the model

The demographic-health sub-model

Mortality

Let $m_{ij}^{actual}(t)$ be the actual historical mortality rate, and $m_{ij}^{model}(t)$ the rate predicted by our model. In projections we assume that

$$m_{ij}^{model}(t) = m_{ij}^{actual}(t_0)\left[1+b\right]^{t-t_0}, \ t > t_0. \tag{32}$$

To help choose plausible values for b to use in projections, we run the model backwards and look for a value of b that provides the best fit to historical data for the period 1950/51-2000/01. “Best” is defined here as minimizing squared errors. That is, we find the value of b that minimizes the quantity

$$\sum_i \sum_j \sum_{t<t_0} \left[m_{ij}^{model}(t) - m_{ij}^{actual}(t) \right]^2 = \sum_i \sum_j \sum_{t<t_0} \left[m_{ij}^{actual}(t_0) \left[1+b \right]^{t-t_0} - m_{ij}^{actual}(t) \right]^2, t < t_0 \quad (33)$$

When the summation is carried out over all age groups, the best fit is obtained with $b = 0.60$. When the summation is only performed for ages less than 80, so that age groups 80-84, 85-89, 90-94, and 95+ are excluded, the best fit is obtained with $b = 1.46$. There are two reasons for thinking that the value of 1.46 is a better guide to the future than 0.60. First, New Zealand's historical mortality estimates for the highest age groups are not particularly reliable. Second, mortality rates at older ages in many developed countries have recently begun declining at least as quickly as mortality rates at younger ages, suggesting that the earlier absence of decline was only temporary.

Decedents and survivors

The numbers of decedents $P_{ij}^{d}(t)$ in age group i and sex j can be estimated from age-sex specific mortality rates $m_{ij}(t)$. Contributions to the total number of person-years lived by decedents of age group i in year t are made by the following people: (1) all those who die in year t while in age group i; (2) most of those who die in year t+1 while in age group i; (3) some of those who die in year t while in age group i+1; and (4) some of those who die in year t+1 while in age group i+1. The majority of person-years are contributed by (1) and (2), so we use the approximation

$$P_{ij}^{d}(t) = \tfrac{1}{2} m_{ij}(t) P_{ij}(t) + \tfrac{1}{2} m_{ij}(t+1) P_{ij}(t+1). \quad (34)$$

Values for $P_{ij}^{s}(t)$ are obtained by subtracting $P_{ij}^{d}(t)$ from $P_{ij}(t)$.

Disabled and non-disabled

We simply use the expressions $P_{ij}^{u}(t) = u_{ij}(t) P_{ij}(t)$ and $P_{ij}^{w}(t) = P_{ij}(t) - P_{ij}^{u}(t)$.

Non-disabled decedents, disabled decedents, non-disabled survivors, and disabled survivors

Let z_{ij} be the proportion of deaths in age group i and sex j that are attributed in the 2001 cause-of-death statistics to "injury". We use these proportions to estimate the proportion of decedents whose death was not preceded by chronic illness. With one exception, we assume that

$$P_{ij}^{dw}(t) = z_{ij} P_{ij}^{d}(t), \text{ for ages 0-64}$$

$$P_{ij}^{dw}(t) = \tfrac{1}{2} z_{ij} P_{ij}^{d}(t), \text{ for age 65 and over.} \quad (35)$$

The exception occurs when this method implies a disability prevalence that is lower than $u_{ij}(t)$. In these cases (which occur during back-casting), we assume that $P_{ij}^{dw}(t) = u_{ij}(t) P_{ij}^{d}(t)$.

Values for $P_{ij}^{du}(t)$, $P_{ij}^{sw}(t)$, and $P_{ij}^{su}(t)$ are obtained using Equations (12)-(16).

Government health expenditure versus Vote Health

Let $VH(t)$ be actual Vote Health expenditure in year t, $VH^{93}(t)$ expenditure on the basket of services funded under Vote Health in 1992/93, and $VH^{02}(t)$ expenditure on the basket of services funded under Vote Health in 2001/02. Let $NT(t) \equiv VH(t) - VH^{93}(t)$ be net transfers in year t (where $t = 1993, 1994, \ldots, 2002$). Net transfers measure expenditure on services that were funded out of Vote Health in year t but were not funded out of Vote Health in 1992/93. By definition, $VH^{93}(1993) \equiv VH(1993)$ and $VH^{02}(2002) \equiv VH(2002)$. We want to derive values for $VH^{02}(t)$ for $t = 1951, 1952, \ldots, 2001$.

The first step is to derive a complete series for $VH^{93}(t)$. For $t = 1994, 1995, \ldots, 2002$, we use $VH^{93}(t) = VH(t) - NT(t)$. For $t = 1951, 1952, \ldots, 1992$, we use the assumption that the range of services provided under Vote Health remained the same as in 1992/93, so that $VH^{93}(t) = VH(t)$.

The second step is to use the series for $VH^{93}(t)$ to derive a series for $VH^{02}(t)$. Our assumption is that $V^{02}(t) / V^{93}(t) = V^{02}(2002) / V^{93}(2002)$. By rearranging to give $V^{02}(t) = \left(V^{02}(2002) / V^{93}(2002)\right) V^{93}(t)$, a series for $V^{02}(t)$ can be calculated.

Appendix 3 – International Evidence on Disability Trends

Only two national surveys of disability have been done in New Zealand – in 1995 and 2001 respectively (Statistics New Zealand 1998, 2003). In the absence of a long time series of historical data, projection of disability prevalence was based on a comparative analysis of national disability surveys in other developed countries (as well as the New Zealand surveys). The method and results are briefly summarised below.

Method

A systematic review of the literature on trends in disability prevalence in developed countries was undertaken. The search methodology included a MEDLINE search of the literature (from which key review articles were identified) and a search of selected government health and statistical websites (from which key surveys and their results were identified). Note that different definitions of disability used in different studies mean that *levels* cannot be compared across countries, but *trends* can.

Criteria

Criteria for selection of studies were:

- Cohort study or serial cross sectional prevalence survey
- National in coverage
- Institutionalised population included (that is, those living in a residential facility that is not community based)
- Long duration, including at least five years in 1990s
- Outcomes measures able to be translated into a scale of disability rates, with ADL (severe) and IADL (moderate) limitations
- Minimal changes in data collection and analysis methods
- High participation rate / low rate of loss to follow up (cohort studies only)
- Minimal use of proxy responses
- English speaking country

Not all studies included met all criteria. Specifically, the Framingham Heart Study was included despite being non-national and excluding institutionalised people, because of its long follow up period and use of observational rather than self report measures of disability. On the other hand the US National Health Interview Survey (including its Supplements on Aging) was excluded as it proved difficult to express its endpoints in terms of severe (ADL) and moderate (IADL only) disability.

In all, 7 studies were included, comprising 5 serial cross sectional prevalence surveys and 2 longitudinal (cohort) studies. The latter, both of which are US studies (the National Long Term Care Study and the Framingham Heart Study) are considered more reliable and valid than the former, both because of their design and because of the extremely high standard of follow up, measurement and analysis achieved in both these two cohort studies.

Selected studies

Country	Study	Waves	References
New Zealand	Postcensal Disability Survey	1996	SNZ (1998)
		2001	SNZ (2003)
Canada	Postcensal Disability Survey	1986 HALS	Statistics Canada (2002a, 2002b)
		1991 HALS	
		2001 PALS*	
Australia	ABS Survey of Disability	1988	ABS (1990)
		1993	ABS (1996)
		1998**	Davis et al (2001)
England	Health Survey for England	1995	HSE 1995 (UK Department of Health 1997)
		2001	HSE 2000-01 (UK Department of Health 2003)
US I	National Long Term Care Study	1982 - 1999	Manton and Gu (2001)
			Freedman et al review (2002)
US II	Framingham Heart Study	1977 –1994 Framingham	Allaire et al (1999)
			Freedman et al review (2002)
US III	Medicare Current Beneficiary Survey	1992 – 1996Medicare CBS	Waidmann and Liu (2000)
			Freedman et al review (2002)

*major method drift from earlier waves
**method drift from earlier waves rectified post hoc (Davis *et al* 2001)

Analysis

A standard template was developed and used to extract key data from the published results of the selected studies. Initially study results were converted into estimates of prevalence of moderate (IADL only) and severe (ADL) disability, if required. This was done for each ten year age group included in the study (there was variable age restriction across studies) and both genders.

A summary table was then prepared, showing age standardised prevalence of moderate and severe disability for the total adult population of each country (standardised to the WHO World population), with genders pooled. We pool genders because the underlying dynamic in disability prevalence should not be gender specific at least in terms of direction of change. The only exception to this is NZ, as indicated.

Finally we converted the change between extreme periods for each study to an average annual percentage change, assuming exponential behaviour.

Results

Prevalence of disability

		1996	2001		
NZ	moderate	8.0	8.4		
	severe	2.4 (males)	2.6 (males)		Gender difference
		3.4 (femal)	2.8 femal)		

		1986	1991	2001	
CAN	moderate	6.6	6.7	7.5	2001 not comparable
	severe	2.0	2.1	2.0	

		1988	1993	1998	
AUS	moderate	8.7	8.0	8.8	1998 comparability 'rectified'
	severe	4.4	4.4	5.5	

		1995	2001		
UK	moderate	13.5	12.0		
	severe	4.0	5.0		

		1982	1989	1999	
US I (NLTCS)	moderate	13.6	13.4	12.4	Only first, middle and last waves shown
	severe	5.7	4.8	3.2	

		1977	1994		
US II (Framingham)	moderate	22.6	13.0		Noninst pop of one town only
	severe	1.1	0.8		

		1992	1996		
US III (MCBS)	moderate	13.7	12.0		Very short interval
	Severe	4.3	5.0		

Average annual percentage change (exponential)

	NZ	CAN *	AUS	UK	US I	US II	US III
Mod	+0.9	0.0	0.0	-2.4	-0.6	-3.5	-3.3
Sev	-1.1	0.0	+2.3	+2.5	-4.2	-5.5	+3.8

* HALS 1986 – 1991 only; HALS not comparable with PALS

Conclusions

Results consistently show a *decrease* in prevalence of moderate (IADL only) disability over recent decades (mainly 1990s), although this is less evident in the Australasian surveys.

With the exception of the two major US studies and the NZ study, results are also consistent in showing an *increase* in severe (ADL) disability.

Given the greater reliability of these US studies, and assuming that they may foreshadow what will happen later elsewhere, it seems reasonable to conclude that severe disability prevalence is unlikely to increase in NZ but will probably stabilise or even decrease.

It is interesting that no study shows the anticipated decline in severe disability compensated by an increase in moderate disability (predicted under the 'dynamic equilibrium' theory of Manton (1982) except for the New Zealand study.

Plausible range for modelling

As we are interested in severity-weighted disability prevalence over the next fifty years, we need to weight the estimated trends for severe vs moderate disability. The former involves at least twice the level of consumption of health care and disability support resources as the latter. On the other hand, the prevalence of moderate disability is at least twice that of severe disability (eg approximately 8% vs 3% overall in New Zealand). Hence equal weighting of the two series seems an appropriate choice.

Given this weighting, the possible rise in severe disability is more than compensated for by the very consistent fall in moderate disability, with the result that the plausible range may be concluded to vary from stability to a gradual decline. A future increase in severity-adjusted disability prevalence appears unlikely based on this analysis.

The range in "DIS" (average annual relative change in disability prevalence) selected for this study was therefore 0.0 to –1.0 percent per year. The sensitivity analysis has been done using average annual reduction rates of 0.0% (high disability prevalence), 0.5% (medium disability prevalence) and 1.0% (low disability prevalence) respectively, for all age-sex cells.