# Rebalancing health service use for older people: simulating policy-relevant scenarios under demographic ageing

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## ABSTRACT

**AIMS:** The demographic ageing of New Zealand society has greatly increased the proportion of older people (aged 65 years and over), with major policy implications. We tested the effects on health service use of alterations to morbidity profile and the balance of care.

**METHODS:** We developed a microsimulation model using data from an official national health survey series to generate a synthetic replicate for scenario testing.

**RESULTS:** Projections on current settings from 2001 to 2021 showed increases in morbidity—long-term illness (2%)—and in health service use—doctor visits (21%), public hospital admissions (16%). Scenarios with decreasing morbidity levels showed moderate reductions in health service use. By contrast, rebalancing towards the use of practice nurses showed a large decrease in public hospital admissions for people aged 85 years and over.

**CONCLUSION:** Demographic ageing may not have a major negative effect on system resources in New Zealand and other developed countries. Rebalancing between modalities of care may soften the impact of increasing health service use required by a larger older population.


The demographic structure of New Zealand, as in other developed countries, is changing. The proportion of older people in the population has greatly increased—along with their experience of multi-morbidity—with major implications for the provision of health services.[1,2] Forecasts of future compression or expansion of morbidity hinge on whether extended life-expectancy will be spent largely in good or ill health.[3] Nevertheless, there is pressure on available resources to keep pace with the sheer increase in volume of health care required for larger numbers of older people. The recent World Health Organization's 'World Report on Ageing and Health' proposes a public-health framework for healthy ageing—defined as "the process of developing and maintaining the functional ability that enables well-being in older age"—in which the first of four priority areas is "aligning health systems to the needs of older populations" (p 13).[4] The policy quandaries posed by demographic ageing apply no less to New Zealand,[5] with the proportion of people aged 65 years and over projected to increase by nearly two-fifths from 12.1% in 2001 to 16.8% in 2021.[6]

## Aims

We aimed to model a range of policy scenarios on the future shape of the New Zealand health-care system under conditions of demographic ageing. To do this, we constructed and applied a discrete-time dynamic microsimulation model to health service use in older people. Here, we define health services as a balance of three modalities: practice nurse visit, family doctor visit and public hospital admission. We report on the construction of the model and the results of projections and scenario testing.

## Research questions

After establishing a baseline for our model, we aimed to address two key policy initiatives proffered internationally: promoting healthier ageing to reduce the need for health care[7] and changing the balance of care[8] towards more effective configurations.[9] We focussed on testing scenarios where the burden on the health system might be lessened. Our research questions can be formalised as follows:

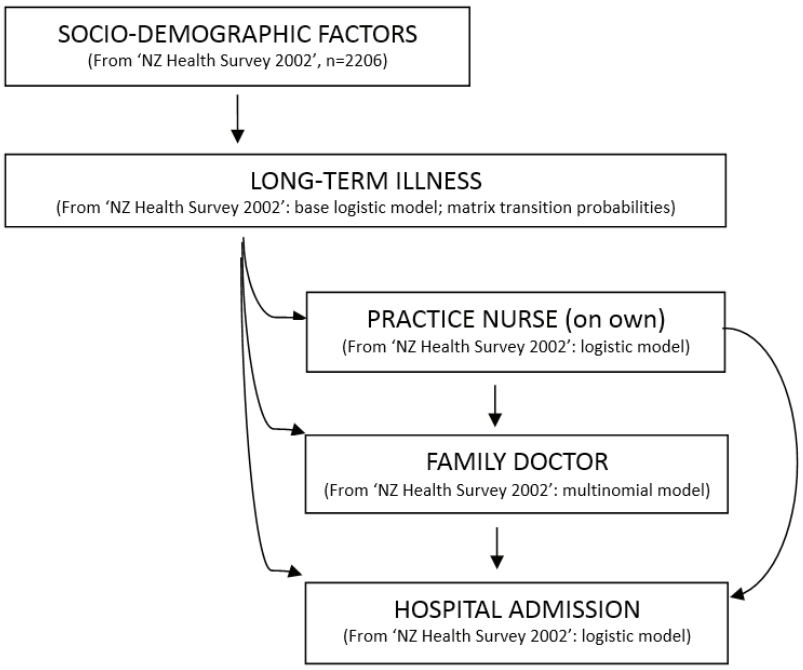
1. What will be future levels of health service use for older people under the status quo? This is our 'base projection'.
2. What is the impact of reducing morbidity levels—proxy for healthier ageing (and the compression of morbidity)—on health service use of older people? This is our 'reduced morbidity'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

The model (Figure 1) was: (1) hierarchically structured—with long-term illness (morbidity) driving health service use, with practice nurse use affecting family doctor use (via potential prevention or substitution) and with practice nurse and family doctor use affecting public hospital admission (via potential prevention or delay)—and (2) dynamic—incorporating demographic and morbidity changes over time.[10]

## Microsimulation

Microsimulation—first proposed by Orcutt[11] in 1957—has been used, for example, to assess the impact of demographic aging on population health.[12] Microsimulation relies on data from the real world to create an artificial version like the original. It operates at the level of individual units (here older people), each assigned attributes as a starting point—eg age and health state, to which quantitative rules (eg statistical equations) are applied to simulate changes in state or behaviour. Thus a synthetic set of typical life histories can be generated. The model can then be used to test scenarios—essentially thought experiments—by modifying key factors and assessing impact on outcomes of policy interest.[13,14]

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




Long-term illness drives health service use, with practice nurse use affecting family doctor use and public hospital admission, and with family doctor use affecting public hospital admission.

# Methods

Our methods are outlined briefly in this section with a detailed report published online.[15] Microsimulation was adopted as a technical approach well-suited to modelling the dynamics of a complex system such as health care, and for testing policy scenarios related to utilisation.

## Data sources

We used individual-level data on older people aged 65 years and over from the New Zealand Health Survey undertaken in 2002 and 2006 (NZHS 2002 and 2006).[16] As well as the person's demographic characteristics, there was information on whether they had long-term illness, and on their use of health care; NZHS was the only national data source available with these features. These survey data had the advantage of being nationally representative and relatively recent with adequate sample sizes. NZHS sample weights were taken into account in analyses and simulations. The NZHS 2002 contributed data on 2,206 individuals to form a starting sample at the base year, set to 2001, providing initial conditions representative of older people living in the community. A description of characteristics of the starting sample can be found in Table 1. Thus 9.3% were aged 85 years and over while 85.6% were experiencing long-term illness.

**Table 1:** Description of starting sample. Characteristics of older people (aged 65+ years) living in the community, 2001.

| Characteristic | Percentage of weighted sample† (n=2206) |
|---|---|
| **Age group** | |
| 65–74 | 54.2 |
| 75–84 | 36.5 |
| 85+ | 9.3 |
| **Gender** | |
| Female | 55.3 |
| **Ethnicity** | |
| European | 91.8 |
| Māori (the indigenous people) | 4.0 |
| Pacific | 1.7 |
| Asian | 2.2 |
| Other | 0.3 |
| **Marital status** | |
| Partnered | 56.5 |
| **Deprivation decile** | |
| 1 (low deprivation) | 6.5 |
| 2 | 7.6 |
| 3 | 9.3 |
| 4 | 10.4 |
| 5 | 10.1 |
| 6 | 13.5 |
| 7 | 10.6 |
| 8 | 13.8 |
| 9 | 11.1 |
| 10 (high deprivation) | 7.3 |
| **Long-term illness** | |
| Present | 85.6 |

† The starting sample was taken from the New Zealand Health Survey 2002/3 (Ministry of Health 2004), with weighting calibrated to the New Zealand Census 2001.

## Definition of variables

The following individual characteristics incorporated in the model can be categorised into three types:

**1.** Socio-demographic

- Age: 65+ years.
- Gender: male, female.
- Self-reported ethnicity (in prioritised sequence): Māori, Pacific, Other, European. A single ethnicity variable was constructed to account for individuals who reported multiple ethnic affiliations.[17]
- Socio-economic deprivation: 'NZDep' (decile)—a census-based small-area measure.[18]
- Self-reported partnership: married, or partnered and not legally married (yes/no).

**2.** Morbidity

- Self-reported long-term illness (yes/no): any medical condition lasting six months or more.

**3.** Health service use (outcomes)

- Self-reported health service use (in the last 12 months): any practice nurse visit—formal consultation with nurse on their own, ie without seeing a doctor (yes/no); family doctor visit categories 0, 1–2, 3–4, 5–6, or 7+ visits (yes/no, in each category); public hospital admission for any reason, comprising inpatient and day patient (yes/no). For family doctor visits, simulated results are reported for the combined '5+ visits' category signifying a high user group.

## Analysis

Firstly, transition probabilities for long-term illness were estimated from matrices using repeated cross-sectional data (NZHS 2002 and 2006), depending on age and gender (use of other characteristics was constrained by small numbers). This estimation was based on known long-term illness levels in 2002 and 2006, and assumed that an individual could remain in the same state or progress to the next state but not revert to a former state. These results imparted dynamic change to the cross-sectional models of health service use (as below).

Secondly, we used cross-sectional data (NZHS 2002) to predict health service use from long-term illness (as above) in a series of regression models: practice nurse visit—logistic, family doctor visit (as categories)—multinomial and public hospital admission—logistic. Earlier events or states could exert an influence over later ones (Figure 1). Thus, practice nurse visit was a function of long-term illness; while family doctor visit was a function of both long-term illness and practice nurse visit; and finally public hospital admission was a function of long-term illness, practice nurse visit and family doctor visit. Age, gender, ethnicity, deprivation level and partnership status were also accounted for as potential socio-demographic control variables while, for each model, only statistically significant ones were retained.

## Simulation

From 2001, we applied parameters (derived from statistical analysis of NZHS data) to update time-variant attributes of 2,206 individuals (in the starting sample) at five-year intervals using Monte Carlo simulation. The simulation process for each subsequent time interval followed a sequence of steps from demographic characteristics, through health status, to final health care outcomes. To reduce the effect of random error, a simulated estimate was taken as the average result of 20 runs, sufficient to generate a stable value. Thus a set of typical though varied individual life histories was created. To maintain a representative sample over time, at each five-yearly interval, we allowed individuals to enter (being randomly drawn from 65–69 year-olds from NZHS 2002) and to die (according to probabilities from official period life tables), as well as re-weighting (according to official population statistics) to account for demographic changes in composition (eg due to migration).

## Validation

Validation of simulated results was carried out by comparison to actual NZHS 2006 data (the latest available). The test was whether the simulation model could reproduce benchmark averages and distributions. Where necessary and possible, simulated results were calibrated to population parameters (from NZHS, censuses and official

projections) so that findings could be generalised to the national population.

## Scenario testing

Key factors influencing health service use may be considered as potential levers for policy intervention. These can be tested via simulating scenarios. We used the simulated results—with no changes made—as the base case. For each scenario, we changed factors of interest in the starting sample, while holding other initial factors constant, and observed impact on downstream outcomes (compared to the base case). At an individual level, changes were made to those in or at high risk of being in a particular state, eg having long-term illness. Note that the settings for the scenarios were heuristic: we started with small changes in morbidity or care levels and gradually increased or decreased them, over a reasonable range of proportions to an upper limit of possibility (5 to 20 percent).

**1.** *Base projection* of status quo to 2021

We simulated from the starting sample in 2001 forward to 2021 with *no changes* to inputs or parameters. We considered 20 years as a reasonable projection period that would be useful without overstretching the data.

**2.** *'Reduced morbidity' scenario* (2021)

We artificially *reduced*, by varying proportions (5%, 10% and 20% respectively), the prevalence of and transition probabilities for long-term illness to assess impact on levels of health service use.

**3.** *'Balance of care'* scenario (2021)

We artificially *increased*, by varying proportions (5%, 10% and 20% respectively), the level of practice nurse visits to assess impact, in turn, on levels of family doctor visits and public hospital admissions.

# Results

## Validation

The simulated sample followed the general pattern for the real sample (from NZHS 2006) though not uniformly so across all measures: compared to the benchmarks, long-term illness and practice nurse visit were under-estimated while family doctor visit and public hospital admission were over-estimated (Table 2). Note that, in the interpretation of simulated results, greater importance should be placed on direction and magnitude rather than specific point estimates.

**Table 2:** Morbidity and health service use for older people (aged 65+ years) living in the community. Comparing simulated to real data, 2006.

| Age group | Morbidity | | Health care modalities | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Long-term illness (lasting at least six months) (%) | | Practice nurse visit (any in last 12 months) (%) | | Family doctor 5+ visits (in last 12 months) (%) | | Public hospital admission (any in last 12 months) (%) | |
| | Simulated | Real † | Simulated | Real † | Simulated | Real † | Simulated | Real † |
| 65–69 | 78.0 | 86.7 | 42.9 | 43.6 | 36.6 | 31.1 | 18.7 | 14.1 |
| 70–74 | 89.2 | 89.7 | 43.2 | 46.2 | 38.8 | 32.9 | 20.7 | 17.5 |
| 75–79 | 89.8 | 89.6 | 43.7 | 45.8 | 52.0 | 36.8 | 25.5 | 19.7 |
| 80–84 | 93.8 | 94.0 | 44.2 | 48.4 | 52.3 | 42.2 | 26.5 | 25.2 |
| 85+ | 91.1 | 89.9 | 44.6 | 45.2 | 47.9 | 39.7 | 22.5 | 19.1 |
| All (65+) | 86.6 | 89.3 | 43.5 | 45.5 | 43.6 | 35.0 | 22.0 | 18.1 |
| (95% CI)‡ | (86.3–87.2) | | (42.6–44.4) | | (42.6–45.3) | | (21.5–23.1) | |

† Taken from NZ Health Survey 2006.
‡ 95% confidence intervals were calculated from 20 simulation runs.

## Scenario testing

Our comparison between the base simulation (with no changes) and a scenario (with a factor change) were relative to one another within the virtual world. The two simulated results—conditioned on the same input data and parameters—are directly comparable and give a good assessment of impact of the changed factor.

**1.** *Base projection*

Simulation under current settings, ie projection, from 2001 to 2021 showed a moderate absolute increase overall in the level of long-term illness (Table 3) which was more marked with increasing age: 2% for the 65+ age group and 13% for the 85+ age group (results not tabled). There was a concomitant proportional increase in the use—by people aged 65+—of family doctor visits (up 21%) and public hospital admissions (up 16%) while practice nurse visits remained stable (Table 3).

**Table 3:** Base projection and 'reduced morbidity' scenarios. Morbidity and health service use for older people (aged 65+ years) living in the community, 2001 and 2021.

| Simulations† | Morbidity | Health care modalities | | |
|---|---|---|---|---|
| | Long-term illness (lasting at least six months) (%) | Practice nurse visit (any in last 12 months) (%) | Family doctor 5+ visits (in last 12 months) (%) | Public hospital admission (any in last 12 months) (%) |
| Q1. Base projection‡ | | | | |
| 2001 | 85.6 | 42.1 | 36.0 | 18.8 |
| 2006 | 86.6 | 43.5 | 43.6 | 22.0 |
| 2011 | 87.2 | 43.3 | 43.4 | 22.1 |
| 2016 | 86.5 | 43.2 | 42.9 | 21.6 |
| 2021 | 87.4 | 43.3 | 43.5 | 21.8 |
| Q2. 'Reduced morbidity' scenarios§ | | | | |
| Make 5% decrease in long-term illness | | (%) [% change]¶ | | |
| 2006 | - | 43.0 | 42.7 | 20.8 |
| 2011 | - | 43.1 | 42.9 | 21.1 |
| 2016 | - | 43.0 | 42.4 | 21.3 |
| 2021 | - | 43.2 [-0.2] | 42.9 [-1.4] | 21.4 [-1.8] |
| Make 10% decrease in long-term illness | | | | |
| 2006 | - | 42.6 | 41.8 | 19.7 |
| 2011 | - | 43.0 | 42.1 | 20.5 |
| 2016 | - | 43.1 | 41.6 | 20.7 |
| 2021 | - | 43.1 [-0.5] | 42.5 [-2.3] | 21.1 [-3.2] |
| Make 20% decrease in long-term illness | | | | |
| 2006 | - | 42.6 | 40.2 | 18.8 |
| 2011 | - | 42.7 | 41.0 | 19.4 |
| 2016 | - | 43.0 | 40.4 | 19.6 |
| 2021 | - | 43.1 [-0.5] | 41.1 [-5.5] | 20.0 [-8.3] |

† Simulations are calibrated to NZ Health Survey 2006 data.
‡ Base projection to 2021 is on current settings.
§ Scenarios represent the impact of reducing base prevalence of and transition probabilities for morbidity (long-term illness) by nominated percentage of base projected level.
¶ Proportional change in outcome (due to the scenario settings) compared to the base projection for that year.

**2.** *'Reduced morbidity'* scenario

Scenarios projected to 2021, implemented by progressively decreasing long-term illness levels, had the effect of only moderately reducing health service use compared to the base projection (Table 3). For example, with long-term illness levels reduced by 20%, there were proportional reductions of 0.5% in practice nurse visits, 5.3% in family doctor visits and 8.3% in public hospital admissions.

**3.** *'Balance of care'* scenario

Scenarios projected to 2021, implemented by progressively rebalancing towards practice nurse use, had the effect of moderately decreasing family doctor visits but markedly decreasing public hospital admissions—compared to the base projection (Table 4). This effect was much more pronounced with increasing age. This is illustrated by the scenario where the proportion of older persons who visited the practice nurse at least once in a year was increased by 20%. Thus, in the 65+ age group, relative to the basic projection, the proportion of high users of family doctors visits was reduced by 0.7% and the proportion of people admitted to public hospital was reduced by 1.4%; in the 85+ age group those relative reductions were 0.8% and 25.5% respectively (Table 4).

**Table 4:** 'Balance of care' scenarios. Towards more practice nurse visits for older people living in the community, 2021.

| **Simulations†** | **Health care modalities** | | | | | |
|---|---|---|---|---|---|---|
| | Practice nurse visit (any in last 12 months) (%) | | Family doctor 5+ visits (in last 12 months) (%) | | Public hospital admission (any in last 12 months) (%) | |
| | Aged 65+ | Aged 85+ | Aged 65+ | Aged 85+ | Aged 65+ | Aged 85+ |
| Q1. Base projection‡ | | | | | | |
| 2001 | 42.1 | 26.6 | 36.0 | 36.2 | 18.8 | 22.7 |
| 2006 | 43.5 | 44.6 | 43.6 | 47.9 | 22.0 | 22.5 |
| 2011 | 43.3 | 43.8 | 43.4 | 48.9 | 22.1 | 22.8 |
| 2016 | 43.2 | 42.4 | 42.9 | 48.7 | 21.6 | 22.1 |
| 2021 | 43.3 | 42.4 | 43.5 | 48.8 | 21.8 | 23.1 |
| Q3. 'Balance of care' scenarios§ | | | | | | |
| Make 5% increase in practice nurse visits | | | (%) [% change]¶ | | | |
| 2006 | - | - | 43.4 | 47.9 | 21.9 | 22.2 |
| 2011 | - | - | 43.5 | 48.9 | 21.9 | 22.8 |
| 2016 | - | - | 42.9 | 47.6 | 21.7 | 22.3 |
| 2021 | - | - | 43.5 [0] | 50.5 [+3.5] | 21.9 [+0.5] | 22.4 [-3.0] |
| Make 10% increase in practice nurse visits | | | | | | |
| 2006 | - | - | 43.3 | 47.9 | 21.9 | 21.8 |
| 2011 | - | - | 43.5 | 48.9 | 21.8 | 22.5 |
| 2016 | - | - | 42.9 | 47.5 | 21.7 | 21.6 |
| 2021 | - | - | 43.4 [-0.2] | 50.4 [+3.3] | 21.9 [+0.5] | 21.9 [-5.2] |
| Make 20% increase in practice nurse visits | | | | | | |
| 2006 | - | - | 43.3 | 47.5 | 21.8 | 21.0 |
| 2011 | - | - | 43.2 | 47.7 | 21.4 | 18.5 |
| 2016 | - | - | 42.6 | 47.2 | 21.7 | 20.3 |
| 2021 | - | - | 43.2 [-0.7] | 48.4 [-0.8] | 21.5 [-1.4] | 17.2 [-25.5] |

† Simulations are calibrated to NZ Health Survey 2006 data.
‡ Base projection to 2021 is on current settings.
§ Scenarios represent the impact of increasing the level of use of practice nurses by nominated percentage of base projected level, culminating in all individuals visiting the practice nurse at least once.
¶ Proportional change in outcome (due to the scenario settings) compared to the base projection for that year.

# Discussion

The New Zealand health care system, in resource terms, is driven by a complex mix of demand and supply elements, one of which is demographic ageing.[5] We developed and tested a microsimulation model of health service use in older age that may be useful for policy decision-making. The principal findings and their implications will be discussed in the context of each of the research questions posed earlier in the paper. From the results of our simulations, we show *what would happen if* there were policy interventions in place that could increase or decrease current settings in morbidity or health care levels. Discussion of *actual* policy initiatives, their feasibility or effectiveness is beyond the scope of this paper; there are other system improvements that could be made.

## Answering research question 1: Base projection

The base projection under current settings from 2001 to 2021 showed a moderate increase—more marked with age—in long-term illness and in health service use for older people (aged 65+). This assumed that while older people were living longer, they were suffering the same historical pattern of illness. The findings point to the moderate future expansion of morbidity in New Zealand.[19] Furthermore, they indicate that pure demographic ageing—the morbidity impact of a greater number of older people—may not have a major negative effect on health care resources.[20,21] This is consistent with other studies showing, for example, time to death rather than age having the greater impact on health service volumes.[22]

## Answering research question 2: 'Reduced morbidity' scenario

Scenarios in which long-term illness level was decreased—a proxy for healthier ageing and the compression of morbidity—had the effect of moderately reducing health service use. Our findings indicate the limited effect of policy intervention on levels of health service use that are based solely on promoting healthier ageing (while not forgetting its general benefits). The morbidity impact of demographic ageing is complicated by other factors such as: rising living standards and consumer expectations on the demand side and developments in medical technology on the supply side[23] as well as evidence that obesity may give rise to more chronic illness in the future elderly.[24]

## Answering research question 3: 'Balance of care' scenario

Scenarios in which health care was rebalanced towards the use of practice nurses had the effect of reducing family doctor visits and public hospital admissions, being more pronounced in the 85+ age group. Shifting to a modality where substitution is practicable may be arguably more effective with improved patient outcomes. We refer not to directly transferring services for *existing* patients from, for example, hospitals to primary care settings,[25] but to provision of appropriate services geared to *arising* patient need.[26] Thus, for example, visiting a practice nurse for a non-urgent reason such as for advice, screening, monitoring or maintenance activities may avert, prevent or delay the need to see a family doctor or for hospitalisation; and similarly a timely visit to the family doctor may avoid hospitalisation. Depending on life stage, providing appropriate health services may help to prevent the development of chronic illness, slow the decline in functional ability, or manage chronic illness when it occurs.[4] In short, changing the balance of care may make better use of limited system resources[10,27] while sustaining the health of older people.

In New Zealand, the family doctor has traditionally provided the majority of primary prevention and treatment services. In recent times, the role of the practice nurse[28] has become more professionalised with wider scope of responsibility in the primary care team. The practice nurse may be better placed to provide particular services for older people, notably related to care for chronic conditions. As an example, drawing on our findings, a possible policy intervention might be increasing the proportion who visit a practice nurse (at least once in a 12-month period) for the oldest old (people aged 85+) which could substantially reduce the proportions needing to be admitted to public hospital (with potential to generate cost savings).

## Strengths and limitations

The microsimulation approach employed here has many combined advantages: it has an empirical basis; multiple processes are modelled together and contextualised within a system; and pathways are modelled that may be amenable to policy influence. However, it relies heavily on the availability, quality and compatibility of data. In our case, official data sources were particularly advantageous as results from modelling could be generalised to the future population. Data limitations in our case were: a small starting sample; excluding the institutionalised; self-reported information on use of care (not need nor supply); restricted definitions of both long-term illness (rather than disease-specific) and health service use (only the core trio of modalities); narrow range of explanatory variables; no longitudinal data to derive transition probabilities for long-term illness (matching only by age and gender); no accounting for amenable conditions or multi-morbidity; and no costing information.

However, the data used were the most recent and suitable, available at the time modelling was undertaken; time has passed but the underlying dynamic processes are likely still the same particularly over the period of study. The model was able to approximate benchmark data and parameter settings, and substantive results from scenario testing have been plausible and interpretable. In testing a scenario by manipulating a factor of interest, we assumed that other initial conditions and relationships between factors remained the same. Scenario testing generally showed modest impact on outcomes with a degree of stability in the model perhaps due to the interplay among both promoting and inhibiting factors. This may be an accurate reflection of a reality that is complex. Our model is a simplification—with its specific assumptions and modelling choices, and somewhat gross scenarios—but it may be considered as indicative, stimulating further research, and fitting alongside other evidence for policy.

In policy terms, the model has not been able to take into account health reforms in New Zealand since 2001. For example, there have been initiatives to increase access to primary care[29]—which may increase utilisation—and to develop integrated care (across both health and social components)[30]—which may reduce overall health service use.

# Conclusions

We constructed a microsimulation model of older age using official data and applied it to a substantive health policy area. The model serves as a starting point with the potential to be improved and extended. Findings suggest that the system is robust to change. Adding to the international debate, our model indicates that demographic ageing may not have a major negative effect on system resources in developed countries. Furthermore, the sheer volume of health services required, with larger numbers of older people, may be alleviated not only by healthier ageing but also by rebalancing health care to make better use of limited resources.

**Competing interests:**
Nil.

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