Title: Primary care in an ageing society - Building a microsimulation model for policy purposes

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Abstract

Aims:
To develop a micro-simulation model of primary medical care in New Zealand and to test the impact of demographic ageing.

Methods:
Micro-level data from multiple sources - the New Zealand Health Survey (1996/7 and 2002/3) and the National Primary Medical Care Survey (NatMedCa, 2001/2) - were statistically matched to create a representative synthetic base-file of over 13,000 individuals. Probabilities of health experiences and general practitioner (GP) use from the Australian National Health Survey (1995), and of GP activity from NatMedCa respectively were derived. A micro-simulation model was developed that applied these probabilities via a random allocation process to individuals in the base-file. Iterative verification and validation were undertaken to continuously improve the model. Final outcomes simulated were: the number of visits in a year, the distribution of health conditions, and GP levels of investigation, prescription, non-drug treatment, follow up and referral. Scenarios of demographic ageing, community support and practitioner repertoire were tested by changing characteristics of the synthetic population.

Results:
The model imputed a health history over a year to each synthetic individual. Verification showed that the model was able to reproduce expected results and was operating according to design specifications.
The final outcomes produced by simulation were validated against actual data within acceptable error.
Various scenarios, assuming moderate demographic ageing, were tested by a forward projection to 2021 which showed little change in the final outcomes.

Conclusions:
Using a novel micro-simulation approach, a working model of primary medical care in New Zealand 2002 was constructed which produced plausible results. Furthermore, the model was able to be used to test the impact of demographic ageing, community support and practitioner repertoire. There is potential for an enhanced model to become a useful tool for policy purposes.

Introduction

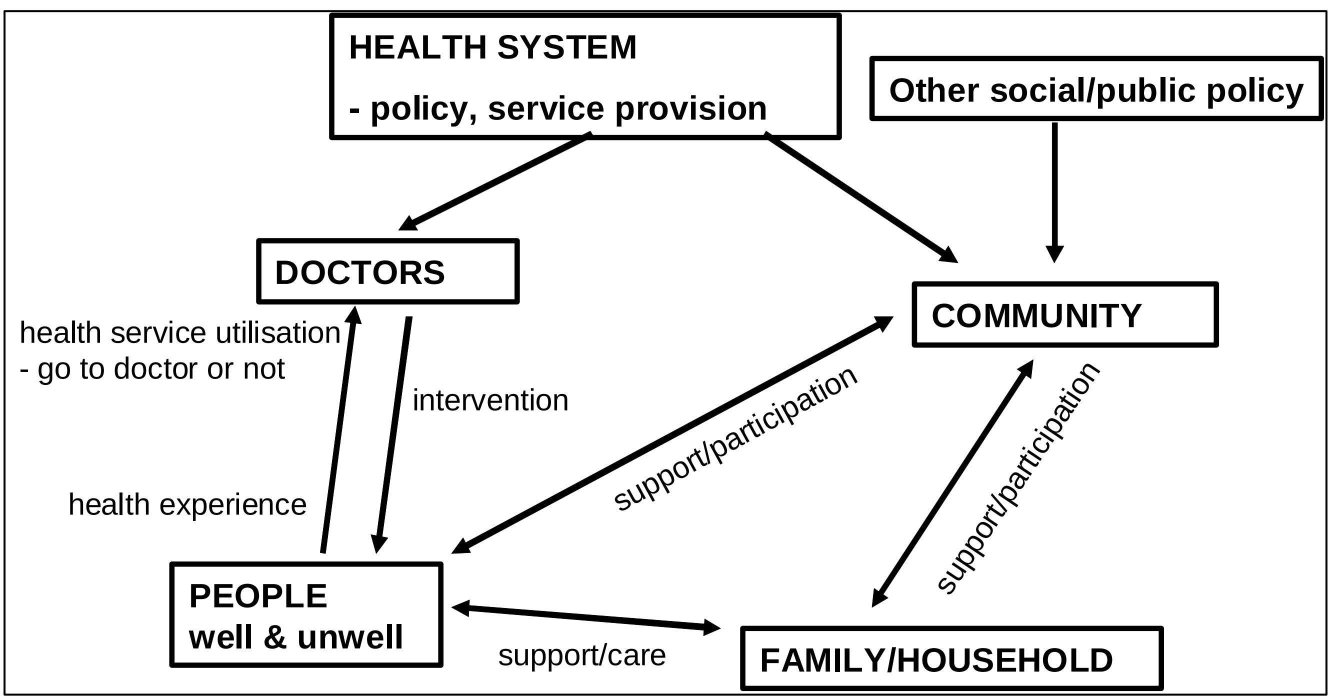
The primary stimulus for this investigation is the appreciation that demographic ageing has major implications for the future of primary care *(Bryant et al 2004; Garces et al 2003; Lloyd-Sherlock 2000)*. In particular, the impact of different models of population health evolution has not been evaluated *(Fries 1980; Kramer 1980; Manton 1982)*. A further rationale is twofold – technical and policy-based. The technical rationale is that health services research in primary care has failed to deal with the sector as a complex, interconnected and evolving system understood within its broader social context *(Gabe 1991)*. The policy argument is that the primary care sector, as traditionally constituted in New Zealand and similar jurisdictions, is under challenge from a number of interconnected social trends, foremost of which is demographic ageing *(Moore et al 2003; Sox 2003)*. A rapidly ageing population has considerable implications for public health expenditure *(Ministry of Health 2004b; OECD 2006).*

We used micro-simulation to mimic the heterogeneity of the population and the complexity of relationships in the primary care setting *(Brown et al 2002; Fone et al 2003).* Micro-simulation operates at the level of individual units – persons, in our case. Each person has a unique identifier and a set of associated attributes, e.g. fixed age, gender, ethnicity. A set of rules is applied to these persons to simulate changes in state and behaviour. This produces estimates of the resulting outcomes, possibly over many time steps, including both aggregate and distributional effects.

Aims

The overall aim of the project is to establish a working, computer-based model of the primary care system (see Figure 1) in New Zealand in its social context and to test propositions about its functioning and development under different scenarios of demographic ageing.

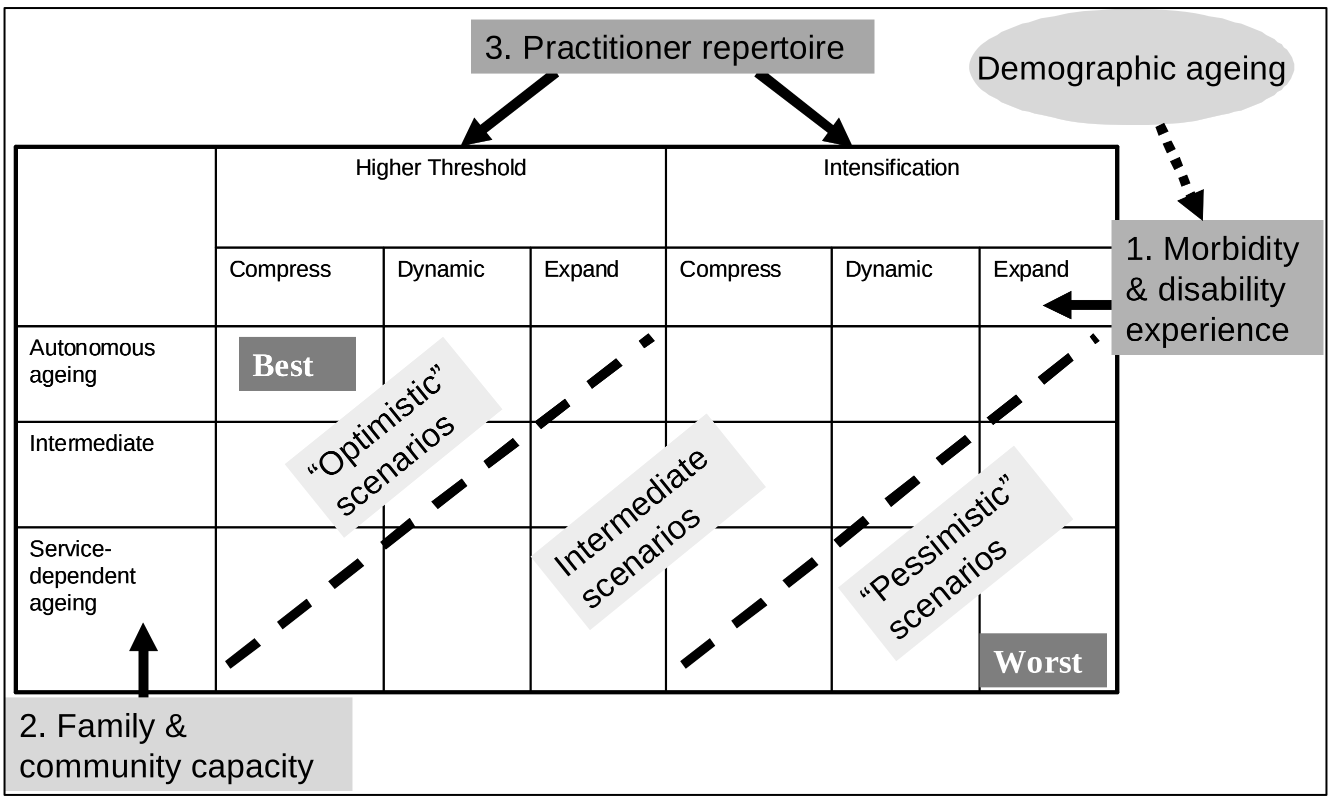
Figure 1. Model of primary health care



Once a working static simulation of the health system as it was circa 2002, i.e. modelling just one year, has been developed and validated using existing data sources, the project will investigate the impact on the system of the following scenarios (see Figure 2):
(a) the impact of demographic ageing on morbidity experience (compression of morbidity; expansion of morbidity; dynamic equilibrium); *(Graham et al 2004; Jagger et al 2006; Ministry of Health 2004c)*
(b) family and community capacity in coping (autonomy; dependency; intermediate); *(Aboderin 2004)*
(c) practitioner repertoire (intensification of rates of intervention as practice population ages; raising of intervention threshold with new cohorts) *(Davis et al 2002, 2002).*

The project will also apply this simulation framework to extrapolated data for a year sometime in the future, i.e. 2021.

Figure 2. Core scenarios



Methods

Preamble

For each individual in the synthesized base file, a health history over a year was created by firstly imputing health experiences and any visits to the doctor, and secondly imputing associated doctor activity. By applying these rules, the model simulates outcomes based on probabilities and random allocation. This static model can be thought of as modeling the New Zealand population of 2002, as the inputs to the models were derived from data of approximately that period. The model was verified and validated to an acceptable level via an iterative process. It could then be used to project forward in time, and policy-sensitive factors were able to be varied. Data manipulation and model implementation were programmed using SAS software *(SAS 9.2, SAS Institute Inc, Cary, NC, USA)*.

Data sources

The model used data from multiple sources: New Zealand Health Survey (NZHS, 1996/7 and 2002/3) *(Ministry of Health 1999, 2004a)*, National Primary Medical Care Survey (NatMedCa, 2001/2*) (Raymont et al 2004)*, and Australian National Health Survey (ANHS, 1995) *(Australian Bureau of Statistics 1996, 1997)* (see Table 1).

Table 1. New Zealand and Australian data sources

Study	**National Health Surveys (NZHS)**	**National Health Survey (ANHS)**	**General Practice Survey (NatMedCa)**	**General Practice Survey (NatMedCa)**
Country	New Zealand	Australia	New Zealand	New Zealand
Year	1996/7 (children) 2002/3 (adults)	1995	2001/2	2001/2
Sample	Children & adults	Children & adults	Patient visits	Doctors (GP)
N	13,548	53,828	9,272	244

Micro-level data from the NZHSs, representative of the population, and NatMedCa, representative of GP users, were statistically matched to create a representative synthetic base-file of 13,548 individuals each with an assigned general practitioner (GP). The ANHS was used to provide information on population levels of recent health conditions (i.e. conditions occurring in the last 2 weeks that were never seen by a GP as well as those that were), and GP utilization. NatMedCa was used as the source of GP and practice information that was matched with the base file, and as the data for predictive statistical models that derived probabilities of GP actions.

These data sources were selected because of their availability, utility, quality, and compatible time periods and variable specifications. In the absence of information on recent illness in the New Zealand Health Survey 2002/3, it was decided to use the 1995 Australian National Health Survey's occurrence rates of conditions. The demographic makeup of the two countries is comparable (see Table 2).

Table 2. Demographic characteristics of NZ and Australian data sources

Age group	Synthetic base file (NZHS 2002/3 adults plus NZHS 1996/7 children)	Australian Health Survey 1995
0-4	8.1	7.2
5-14	16.3	14.3
15-24	13.1	15.0
25-34	13.9	15.7
35-44	15.5	15.2
45-54	13.1	12.3
55-64	8.9	8.3
65-74	6.0	7.5
75+	5.1	4.5
Gender		
Female	51.2	50.2
Male	48.8	49.8
Household type		
Do not live with adult*	9.6	11.1
Live with adult partner	47.0	47.1
Live with adult but not partnered (incl. children)	43.4	41.8

* adult = person aged 15 or over.

Definition of variables

Age group: 0-24, 25-44, 45-64, and 65+.
Gender: male, female.
Ethnicity: Maori, Pacific, Asian, Other, European.
Household type:
1 = do not live with adult (person aged 15 or over), 2 = live with adult partner (husband/wife or defacto, boyfriend or girlfriend), 3 = live with adult but not partnered.
Recent illness is defined as a condition occurring in the last 2 weeks including both short-term and/or long-term ones. Conditions were classified according to 17 broad categories:

1. Infectious and parasitic diseases
2. Neoplasms
3. Endocrine/nutritional/metabolic/immunity disorders
4. Diseases of blood and blood forming organs
5. Mental disorders
6. Nervous system/sense organ diseases
7. Cardiovascular/Circulatory diseases
8. Respiratory system diseases
9. Digestive system diseases
10. Genitourinary system diseases
11. Complications of pregnancy/childbirth/puerperium
12. Skin and subcutaneous tissue diseases
13. Musculoskeletal and connective tissue diseases

14. Congenital anomalies
15. Symptoms, signs and ill-defined conditions, and disability not elsewhere classified
16. Injury and poisoning
17. Not an illness, non-symptomatic, and 'not stated'.

Most important condition: the condition category, chosen from the conditions present in a fortnight for a person, deemed to be the most important in predicting how many doctor visits that person will have for the fortnight.

Primary diagnosis: the condition category deemed to be the main reason, out of all the conditions a person has in a fortnight, for any given visit.

GP clinical activity: outcome related to a visit (yes/no): investigation, prescription, non-drug treatment, follow up, and referral.

Random assignment of characteristics

Random numbers were used throughout the simulation to convert probabilities, whether from tables (Australian data), or from statistical models (NZ data) into characteristics for an individual. A random number from a uniform distribution between 0 and 1 was first assigned. If that random number was less than or equal to the probability then the characteristic was deemed to be present.

A **cumulative distribution** can be created in order to assign a characteristic where an array of multiple probabilities exists rather than just one probability. Each of these probabilities can be standardised by dividing by the sum to give new probabilities that are thus converted to a scale from 0 to 1. Consequently a random uniform number on the same interval can be used to assign the characteristic.

Implementing the simulation

1. Imputing health conditions

We are predominantly interested in modeling the occurrence of recent conditions as they show the immediate need for engagement with primary care services. Broad categories were chosen based on earlier work using the Australian Health Survey 1995 *(Abello et al 2008; Lymer et al 2006; Lymer et al 2008)*, and modified to ensure compatibility with the NatMedCa 2001/2 survey (NZ).

Occurrence rates of recent conditions in the population (during fortnights, spread across the year of data collection) were derived from tabled data using the Australian Health Survey 1995. These rates were broken down by the 17 condition categories, age group, gender, and household type. Up-rating of these 1995 rates to 2002 level was considered but ultimately not deemed necessary after successful validation of the model (without up-rating). However, adjustments for seasonality were made for the 17 condition categories by using standardized proportions of each condition category present in each month of the year that pertained in the NatMedca 2001/2 data.

Each fortnight in the year (2002) was then simulated in turn. Each person was assigned, using random assignment (as described above), whether they had each one of the 17 recent condition categories for each fortnight throughout the year culminating in a list of such condition categories. Co-occurrence of clinically related condition categories was not considered.

2. Imputing if a doctor visit occurred, and if so the type of visit

We estimated the probability that a person would choose to see a doctor (GP/specialist) about their recent condition(s) in the fortnight. The type of doctor visit was assigned to a person regardless of the particular condition category. It was assumed that the common basis - both condition category and doctor type were assigned according to the person's age group, gender and household type – preserved the link between the condition category and whether they saw the doctor. The doctor type variable consisted of 3 categories: 'GP only', 'GP and specialist', and 'None'. The probabilities for these doctor types (by age group, gender and household type) were derived from the proportion of people in the Australian Health Survey 1995 who had at least one recent condition in the last 2 weeks and had specified one of these types.

3. Imputing the 'Most important condition leading to a visit'

For those people who were allocated at least one doctor visit, the 'most important condition category leading to a visit' had to be designated for each array of conditions in each fortnight. This was needed for the assignment of the number of visits in each fortnight. If there was only one condition present, then obviously that condition was designated as the 'most important'. In the case of more than one condition category being present, the 'most important' was assigned based on a cumulative distribution of the probability of each condition in the array. The probabilities of the conditions were based on the distribution of the first listed reason for a visit using data from the Australian Health Survey 1995. This was to enable a better link between the assigned 'most important condition' and the number of visits distribution both based on the same survey data. Separate distributions were given for each doctor type. A cumulative distribution was then derived and used to assign which condition category for a person was 'the most important condition leading to a visit' taken from the entire bundle of conditions.

4. Imputing number of doctor (GP/Specialist) visits

Data from the Australian Health Survey 1995 on the distribution of number of visits (ranging from 1 to 10 visits) by doctor type and depending on the 'most important condition category leading to a visit in the fortnight' was used to assign the number of doctor visits. This distribution was split up by age group, gender and household type where numbers permitted. From this distribution, probabilities were derived of having 1 or 2 or 3 visits up to a possible 10 visits. A cumulative distribution of these probabilities was then created and used to assign the number of visits.

5. Allocation of number of GP visits

If the doctor type for a person was 'GP only' then the number of GP visits was that assigned from the distribution in the relevant table (as described above). However, if the doctor type was 'both GP and Specialist', then the actual number of GP visits had to be estimated based on an estimate of the proportion of 'GP only' to ' both GP and Specialist' visits.

6. Imputing primary diagnoses

Primary diagnoses for each visit in each fortnight for each person then needed to be assigned. Probabilities that each condition category (out of all possible ones in the fortnight) was a primary diagnosis (assumed to be the first listed diagnosis), were produced via statistical modeling of GP visits using NatMedCa 2001/2 data. Given the particular array of conditions that a person had been allocated in a fortnight, a cumulative distribution was firstly made of these probabilities and then used to assign a primary diagnosis. As the primary diagnosis would be used to assign the likely GP actions for each visit, harmonisation was necessary between the categorisation of conditions in the Australian illness data and New Zealand GP visit data. Initial simulated results of the distribution of condition categories seen over the year showed that, in comparison to the NatMedCa benchmark, the 'Symptoms ...' category was being over-estimated. This 'Symptoms …' category contains items that could be possibly diagnosed by the GP as being in one of the other more well-defined categories and so it was decided to try and re-distribute this category accordingly to see if there would be any improvement.

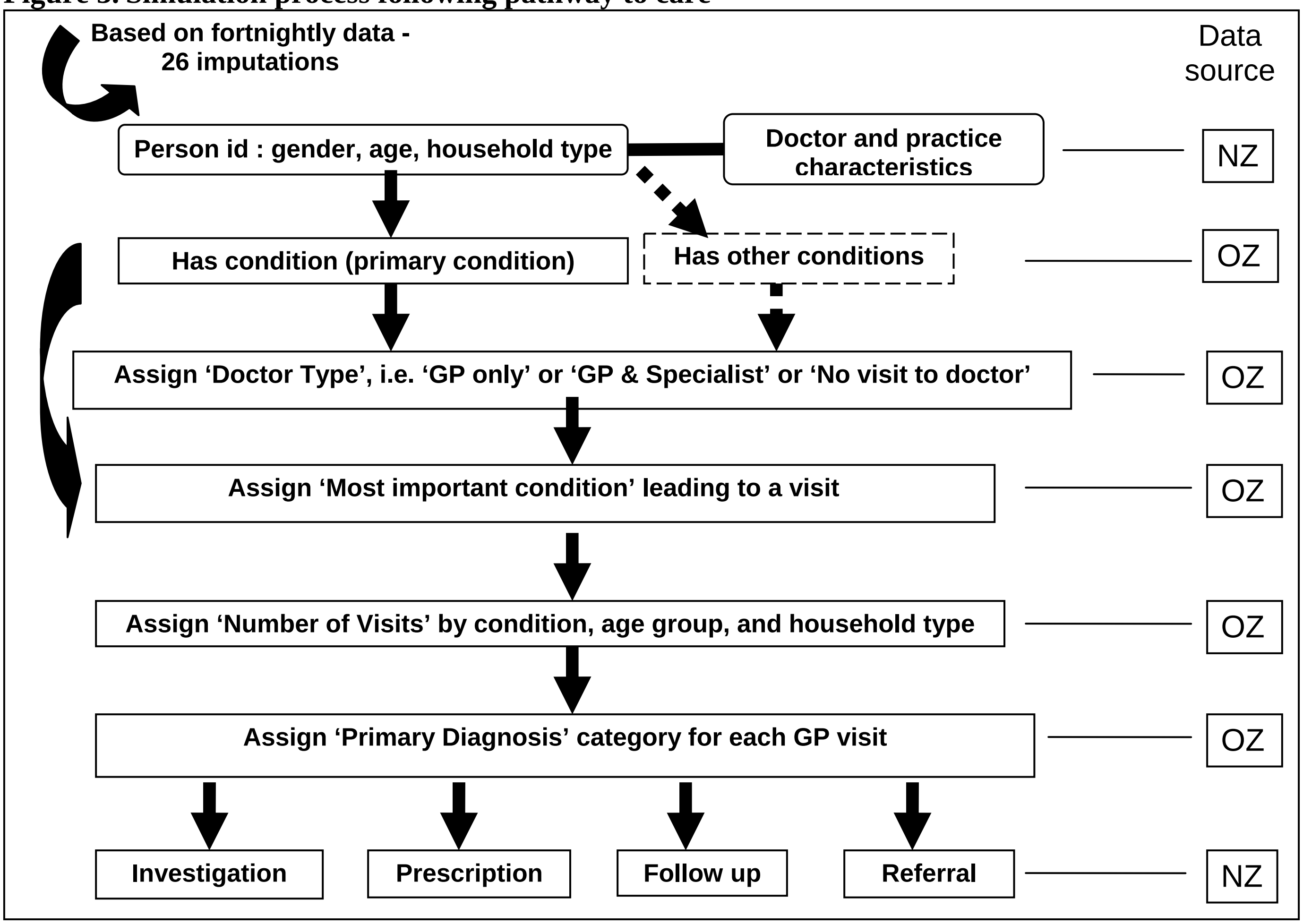
7. Imputing associated GP activity

Given the primary diagnosis, the probabilities of a GP action (investigation, prescription, non-drug treatment, follow-up, or referral) were calculated for each visit via predictions from a statistical model using NatMedca 2001/2 data. Each of these probabilities was then used to randomly assign whether each visit was recorded as having been given each GP action.

8. Summary of simulation process (see Figure 3)

The simulation addressed each fortnight in the year in turn, and imputed if each person had any of the 17 broad condition categories, and if so whether the person saw only the GP, or both the GP and a specialist, or neither. Then depending on the assigned doctor type and 'most important condition', the number of GP visits each person had in each fortnight was estimated. A primary diagnosis was then assigned for each visit which became the basis for deciding whether a GP action (investigation, prescription, non-drug treatment, follow-up, or referral) was given for each visit.

Figure 3. Simulation process following pathway to care



Verification and validation

Verification involved internal checking of the SAS code throughout the simulation program to ensure that variable creation and key components and steps were working properly, and results were being produced as expected.

Validation of the simulation output was done via comparison to external real-world benchmarks, e.g. NatMedCa 2001/2 survey of GPs and their patients.

Scenario testing

This was carried out by simulating a potential outcome by manipulating a variable of interest, while holding other variables constant, and observing change to the outcome.

1. Impact of demographic ageing: Re-weight the population to simulate demographic ageing, i.e. by changing proportions in age group cells.

2. Family & Community Support: Change the distribution of household members (proportion partnered/not partnered).

3. Practitioner repertoire: Change the proportion of younger/older doctors; change the proportion of overseas-trained doctors (via ethnicity).

4. Forward projection: Extrapolate model to 2021 by re-weighting the 2002 population via Statistics NZ projection by age, gender and ethnicity, assuming medium birth, mortality and migration rates. What if the 2002 population looked demographically like the 2021 population with everything else remaining the same?

Results

Verification

Simulated results for key variables, such as ‘recent condition’ occurrence rates and ‘primary diagnosis’ distribution, were found to be similar to their Australian Health Survey 1995 and NatMedca 2001/2 survey benchmarks respectively as would be expected by internal logic.

Validation

In order to externally validate the simulation model’s ability to produce output close to what would happen in the real world, results at each stage were compared to benchmark data from the NatMedCa 2001/2 survey. Comparison was made at an aggregate level, and, where appropriate and possible, also by age group, gender, ethnicity and household type. The aggregate results are presented below.

1. Number of GP visits

When comparing the average number of GP visits in a year, the model overestimated for both GP users alone and more so for the New Zealand population overall. The reasons for this overestimation of visits were (1) based on 2-weekly data multiplied up 26 times assuming independence between fortnights, resulting in too many people having at least one visit in the year and (2) differences in rates of visiting between Australia and New Zealand. Therefore we adjusted the average number of visits in the year by aligning to benchmark New Zealand data (see Table 3).

Table 3. Average number of GP visits per year for GP users and the population overall

Simulation - raw	Simulation - adjusted	NZ target	Absolute error
GP users: 7.5	6.9	6.6	0.3
Population: 7.4	5.5	5.5	0

2. Distribution of condition categories

The aggregate distribution of condition categories for the simulated results against the New Zealand benchmark (GP survey diagnoses) was similar in the rank order by frequency and in the percentages for particular categories (see Table 4). For example, the most frequent category, 'respiratory system disease', contributed 13.5% versus 14.8% respectively. The exception was the 'symptoms, etc' category which is a miscellaneous category where definite classification was not made and which could be reallocated to other condition categories.

Table 4. Condition categories as percentage of all conditions for persons visiting the GP in a year

Condition category	Simulation	NZ GP Survey: Diagnoses	Absolute error
Respiratory system diseases	13.5	14.8	1.3
Cardiovascular/circulatory diseases	9.2	9.3	0.1
Nervous system/sense organ diseases	4.7	8.2	3.5
Injury and poisoning	3.9	7.1	3.2
Skin and subcutaneous tissue diseases	5.1	6.7	1.6
Musculoskeletal and connective tissue diseases	8.8	5.7	3.1
Mental disorders	2.5	5.0	2.5
Genitourinary system diseases	2.7	4.6	1.9
Digestive system diseases	7.0	4.4	2.6
Infectious and parasitic diseases	1.9	4.3	2.4
Endocrine/nutritional/metabolic/immunity disorders	5.4	4.1	1.3
Neoplasms	0.7	2.4	1.7
Diseases of blood and blood forming organs	0.6	0.5	0.1
Complications of pregnancy/childbirth/puerperium	0.1	0.3	0.2
Congenital anomalies	0.1	0.2	0.1
Symptoms, signs & ill-defined conditions, disability nec	12.4	3.5	8.9
Not an Illness, non-symptomatic	21.5	19.1	2.4
Total	**100%**	**100%**	
		Average error	2.2

3. GP activity levels

The simulated levels of different types of GP activity for all visits were similar to those for the New Zealand GP survey benchmark.

Table 5. Percentage of visits per year with each type of GP activity

Doctor activity	Simulation	NZ GP Survey	Absolute error
Investigation	22.2	24.8	2.6
Prescription	54.3	66.2	11.9
Non-drug treatment	60.3	62.0	1.7
Follow-up	55.5	57.2	1.7
Referral	14.2	15.8	1.6
		Average error	3.9

Provisional scenario testing results

1. Projection to 2021

We re-weighted the 2002 population via Statistics NZ projection to 2021, by age, gender and ethnicity, assuming medium birth, mortality and migration rates. The simulation model was re-run on the re-weighted data with everything else remaining the same. There were only slight changes, mostly in the expected directions, in all 3 outcomes, i.e. number of visits, distribution of condition categories, and GP activity levels (see Tables 6-8).

Table 6. Average number of visits per year for persons visiting the doctor: 2002 vs 2021

2002 adjusted	2021 adjusted	Change
6.9	7.2	0.3

Table 7. Condition categories as percentage of all conditions for persons visiting the GP in a year: 2002 vs 2021

Condition category	2002	2021	Absolute change
Respiratory system diseases	13.5	12.8	0.7
Cardiovascular/circulatory diseases	9.2	10.6	1.4
Musculoskeletal and connective tissue diseases	8.8	9.2	0.4
Digestive system diseases	7.0	7.0	0.0
Endocrine/nutritional/metabolic/immunity disorders	5.4	5.8	0.4
Skin and subcutaneous tissue diseases	5.1	4.8	0.3
Nervous system/sense organ diseases	4.7	4.8	0.1
Injury and poisoning	3.9	3.7	0.2
Genitourinary system diseases	2.7	2.6	0.1
Mental disorders	2.5	2.4	0.1
Infectious and parasitic diseases	1.9	1.8	0.1
Neoplasms	0.7	0.8	0.1
Diseases of blood and blood forming organs	0.6	0.6	0.0
Congenital anomalies	0.1	0.1	0.0
Complications of pregnancy/childbirth/puerperium	0.1	0.1	0.0
Symptoms, signs & ill-defined conditions, disability nec	12.4	11.8	0.6
Not an Illness, non-symptomatic	21.5	21.1	0.4
Total	**100%**	**100%**	
		Average change	**0.3**

Table 8. Percentage of visits per year with each type of GP activity: 2002 vs 2021

Doctor activity	2002	2021	Absolute change
Investigation	22.2	22.4	0.2
Prescription	54.3	54.7	0.4
Non-drug treatment	60.3	59.1	1.2
Follow-up	55.5	57.2	1.7
Referral	14.2	14.2	0.0
		Average change	0.7

Although our results showed little proportional relative change overall, the average contribution by the 65 years and over age-group was shown to have increased as expected (from 19% in 2002 to 26% in 2021) and seemed to have translated into not inconsiderable change in absolute numbers (see Table 9).

Table 9. Simulated number of visits per year for persons visiting the doctor 2002 vs 2021

2002								
Age-group	**0-24**	**25-44**	**45-64**	**65+**				
Percentage in age-group	37.4	29.3	22.1	11.2				
Simulated average no. of visits - GP users	6.0	6.8	8.2	12.8	**Total**	**Adjusted**	**Population 2002**	**Estimated total no. of visits***
Contribution to total average no. of visits	2.2	2.0	1.8	1.4	7.5	6.9	3,479,022	19,348,233
% contribution				19%				
2021								
Age-group	**0-24**	**25-44**	**45-64**	**65+**				
Percentage in age-group	34.5	27.5	22.6	15.4				
Simulated average no. of visits - GP users	6.0	6.8	8.2	12.9	**Total**	**Adjusted**	**Projected Population 2021**	**Estimated total no. of visits***
Contribution to total average no. of visits	2.1	1.9	1.9	2.0	7.8	7.2	4,077,222	23,519,119
% contribution				26%				
Increase 2002 to 2021								4,170,886

*Assuming that 80.6% of people have at least one visit in the year (based on NZHS 2002/3)

2. Community Support

In addition to projecting to 2021, when we changed the proportion of people who were partnered and not partnered, again there was a slight decrease in the average number of visits per year for persons visiting the doctor as partnership levels were increased (see Table 10). There was a narrow range of difference, 0.4 visits, in the results between the extreme counterfactuals of all adults being partnered versus all adults being unpartnered.

Table 10. Changing the proportion of people living with partners

			Scenario	Counterfactuals	
	2002	**2021**	**Increase partnered 20%**	**All adults partnered**	**All adults unpartnered**
Average number of visits per year	6.9	7.2	7.1	7.1	7.5

3. GP repertoire
After projecting to 2021, we also changed the proportion of GPs whose ethnic affiliation was European or non-European. The benchmark NZ GP Survey data show that we would expect decreasing the percentage of European GPs should decrease the percentage of visits with an investigation, non-drug treatment, follow up and referral respectively, and increase the percentage of visits with a prescription. The simulation scenarios and, particularly, the counterfactuals all show results in the expected direction, except for percentage with follow up (see Table 11).

Table 11. Percentage of visits with each GP action – by GP ethnicity (European vs. Non-European)

	NZ GP Survey		Simulation scenarios			Counterfactuals	
	European (68.9%)	Non-European (31.1%)	2021 projection	Decrease Euro GPs by 10%	Decrease Euro GPs by 20%	All European	None European
Investigation	25.7	23.3	22.4	22.3	22.2	22.8	21.7
Prescription	65.3	68.0	54.7	54.7	54.7	54.6	54.8
Non-drug treatment	65.7	55.1	59.1	57.6	56.0	64.7	49.0
Follow-up	59.0	56.3	57.2	58.0	58.9	54.3	62.5
Referral	17.0	13.7	14.2	13.8	13.5	15.3	12.2

Discussion

Micro-simulation models are particularly useful for addressing 'what if?' scenarios and realistic extrapolation into the future. In this case, we have attempted to build a model that can be used to test the impact of demographic ageing on primary health care. However, the construction of such a model relies heavily on its foundation of empirical data and hence poses serious challenges.

The major strength of this model lies in its use of existing micro-level data from various relevant sources. There were data available on population occurrence of recent health/illness conditions, GP service utilization, and GP clinical activity. Statistical matching was employed to create a synthetic base file by combining different data sources. This enhancement enabled a better representation of reality than could be achieved from any one source alone. However, the need to harmonise data sources as to, for example, their intrinsic classification categories and time scales, meant that there was potential information that was lost to the model. Furthermore, as longitudinal data were not available to derive proper transition probabilities, the model is a static one so that any extrapolation into the future is hedged with assumptions.

As much as possible, data sources were selected that related to New Zealand and a specific time period circa 2002. The obvious exception on both counts was our use of the Australian National Health Survey 1995 to obtain recent illness information which was otherwise not available. The rationale, borne out by evidence, was that the two countries shared much social similarity and particularly (pertinent here) in their demographic structure and primary health care system. A limitation of the illness and service utilization data (from Australia) was that it was based on a 2-week reporting period so that the simulation of multiple fortnights to create a year resulted in over-estimation due to the fact that actual fortnights are not independent of one another. We also felt justified in aligning our simulated results, e.g. the number of GP visits, to New Zealand 2002 because of identified and quantifiable differences to Australian data.

We attempted to design the simulation process so that it followed as much as possible the pathway to care, i.e. a person becomes unwell, decides to visit a GP or not, and then the GP responds with some kind of action. Effectively, a health history was created for each person in our synthetic population. We attempted to reproduce the realistic linkage from one health event to another embodied by the pathway to care, both logically and chronologically. However, this was not always possible depending on the availability and nature of the data. Therefore, the modelling process has necessarily been an iterative one of continuous verification and validation, with incremental progress, and a balance between the criteria of underlying logical sense and producing stable plausible results.

In testing various scenarios by manipulating specific factors of interest, the model must assume that everything else remains the same including inherent structural relationships. This is a limit on the realism that can be achieved. Our provisional results showed little proportional relative change though that translated to not inconsiderable change in absolute numbers.

Conclusion

A novel micro-simulation approach was successfully applied to a synthetic sample of individuals made by combining existing data sources. A working prototype model of primary medical care in New Zealand 2002 was constructed which produced plausible results. Furthermore, the model was able to be used to test the impact of various scenarios involving demographic ageing via a projection to 2021. There is potential to improve, to increase the complexity of, and to extend the model. This will enhance its usefulness as a scenario-testing tool for policy purposes.

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