A 'whole of system' approach to compare options for CVD interventions in Counties Manukau

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Abstract

Objective: To assess the usefulness of a national and a local system dynamics model of cardiovascular disease to planning and funding decision makers,

Methods: In an iterative process, an existing national model was populated with local data and presented to stakeholders in Counties Manukau, New Zealand. They explored the model's plausibility, usefulness and implications. Data were collected from 30 people using questionnaires, and from field notes and interviews; both were thematically analysed.

Results: Potential users readily understood the model and actively engaged in discussing it. None disputed the overall model structure, but most wanted extensions to elaborate areas of specific interest to them. Local data made little qualitative difference to data interpretation but were nevertheless considered a necessary step to support confident local decisions.

Conclusion: Some limitations to the model and its use were recognised, but users could allow for these and still derive use from the model to qualitatively compare decision options.

Implications: The system dynamics modelling process is useful in complex systems and is likely to become established as part of the routinely used suite of tools used to support complex decisions in Counties Manukau District Health Board.

Key words: cardiovascular diseases, system dynamics, population health, decision making, health care quality access and evaluation

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Cardiovascular disease (CVD) is the most common cause of death in New Zealand (NZ), a major cause of loss of quality of life and an important contributor to ethnic inequities.[1,2] Much is known about the relationship of individual, biomedical, social and health system risk factors and CVD.[3,4] However, there is limited understanding of the relationships and especially the interactions between many of these factors that determine who gets CVD and who does not.[4,5] Even less well understood is the effect on CVD rates from single or multiple interventions in the health or social environment. Health care planners and funding bodies are tasked with making decisions with imperfect information. The uncertainties of decision making are particularly challenging to investments in population health, given the expected long time frame for return on investment and the short time frame for budget accountability. Any tool that can reduce or constrain the uncertainties surrounding the outcomes of long-term of current investments may make it easier for those advocating for population health investment.

Counties Manukau District Health Board (CMDHB), the site of this study, has already committed funds and energy to their Let's Beat Diabetes program, after accepting that the time lag between investment and return may be 10 or more years.[6] The Let's Beat Diabetes program was evolved into the 'Creating a Better Future Strategy' that broadens the activity beyond nutrition and physical activity to include tobacco and alcohol use.

System dynamics modelling is an established tool to aid decision-making in just this type of complex system with much uncertainty and long time frames from action to effect. Developed for the industrial sector by Forrester in the 1950s,[7] it is now used extensively in helping decision makers in the health and social services.[8-11] A national system dynamics model of CVD causation, and potential interventions that may be within the scope of the health care system, was developed during 2008 and 2009 for the Ministry of Health by a consultancy (Synergia) and author Jack Homer, building on work undertaken by the US Centers for Disease Control and Prevention (CDC).[12,13]

Like the CDC model, the NZ model disaggregates the adult population by age

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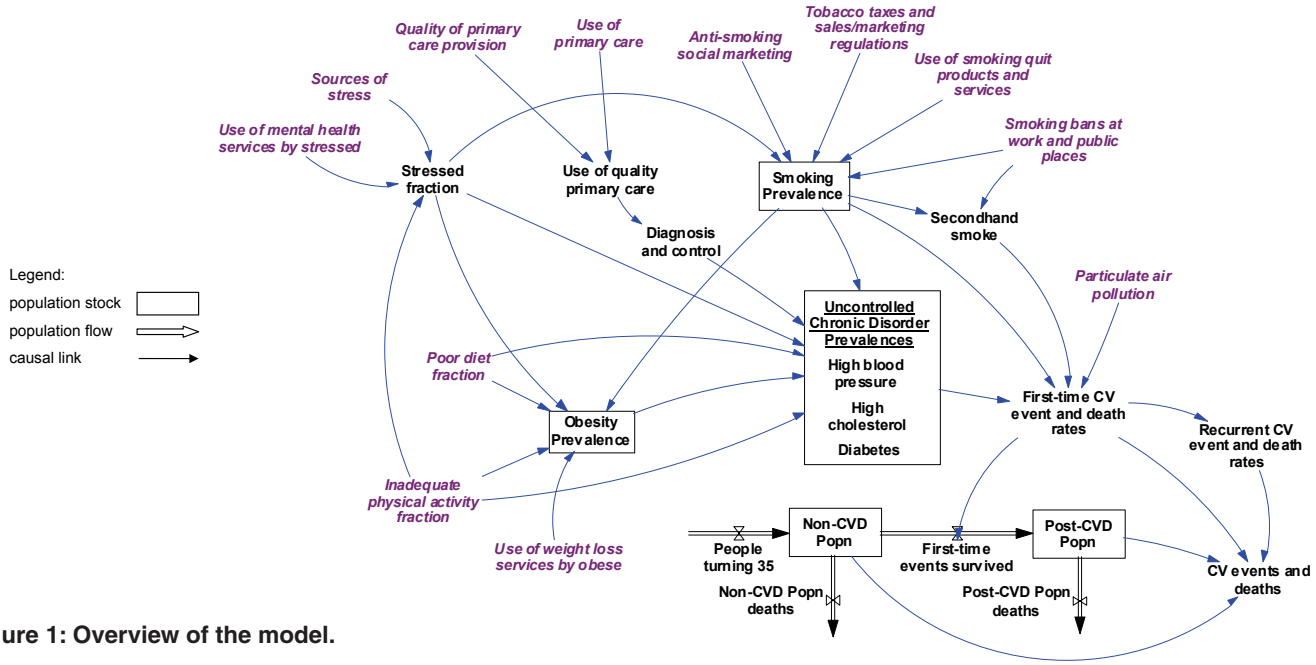


Figure 1: Overview of the model.

group and by gender, and traces the impact of interventions from established cardiovascular (CV) risk factors through to CV events and deaths. The NZ model was built to focus on health outcomes and does not calculate the impact of interventions on medical or productivity costs as the CDC model does. It does go beyond the CDC model by further disaggregating the population by major ethnic group – Māori, Pacific, and European/Other – and so allows for an examination of disparities in a way the CDC model does not.

An important purpose of the NZ model was to determine whether the differences in starting conditions between NZ and the US, or among the different ethnic groups in NZ, would affect model-based policy conclusions. With respect to reductions in CVD deaths, the CDC's US national model indicated a large opportunity from improvements in primary care aimed at better controlling high blood pressure, high cholesterol and diabetes. It also indicated a relatively large opportunity from interventions aimed at reducing smoking, banning public smoking, and reducing small particulate air pollution. It indicated a smaller and more slowly realised opportunity from interventions aimed at improving nutrition and physical activity, reducing obesity, and reducing sources of psychological stress.[12]

The New Zealand Model

Figure 1 shows the overall structure of the NZ model. The model focuses on the 'prevention factors' that influence the first time cardiovascular events and deaths, especially uncontrolled prevalence of diabetes, blood pressure and cholesterol, and the influence of smoking and obesity on those. The main output from the model is a graph showing the numbers of people predicted to have CVD events each year over the next 30 years, comparing the effect in an ideal world (all risk factor variables set to zero) with historical care (i.e. current care) and with changes resulting from any combination of interventions. In addition, the model outputs also show the changes in the risk factors that contribute to those CVD events, thus enabling users to explore the chain of cause and effect that leads to the results they see. Figure 2 shows an example of outputs, by ethnic group, following smoking interventions.

The 'stocks' shown in the overall model structure represent the population, separated into those who have not had a CV event (the 'non-CVD population'), and those who have had a CVD event (the 'post-CVD population'). People enter the 'non-CVD population' by 'turning 35'. People can leave that 'stock' by having a CVD event and surviving or dying, or by dying of some other cause. The model includes the adult population over 35 within each of the three parallel ethnicity models. These populations are further split by gender and two age groups (35-64 and 65 plus). Thus one can explore the impact of a range of interventions on, for example, Māori females aged 35-64, or Pacific males over the age of 65. The detailed simulation model further breaks these categories down to capture those who are obese, those who smoke, those with high blood pressure, those with high cholesterol and those with diabetes.

The entry point at age 35 was chosen for the NZ model due to the current recommendation from the NZ Guidelines Group that 35 be the youngest age for routine cardiovascular risk prediction[14] and the Framingham risk equations starting from age 30[15] and 35.[16] The original US model tracks risk factors from age 18, but cardiovascular events from age 30. The NZ model captures the effects of smoking interventions (such as changes in tax policy) on those younger than 35 by modelling a change in smoking prevalence of those who enter the model at age 35. Interventions to affect obesity are modelled from age 35 but are not modelled to influence the prevalence of obesity on turning 35 – this can be altered by the user as a model input.

Arrows in Figure 1 represent causal links, for example, between 'smoking' and 'uncontrolled chronic disorder prevalences'. The

variables around the outside of the diagram are the policy levers that can be used to test a range of interventions and change the model outputs. For example, one could change the fraction of the population with 'inadequate physical activity'. Following the causal arrows, the model indicates that such a change would have an impact upon 'obesity prevalence'. That would, in turn, affect 'uncontrolled chronic disorder prevalences' which would bring about a change in the number of 'first time CV event and death rates'. The size of effect associated with each of the causal links is informed by data from a range of sources. These include NZ Ministry of Health, NZ Department of Statistics, NZ and international literature, and the Centers for Disease Control and Prevention. Further details about sources are available on request from authors DR or TK.

The model considers two primary care variables: 'quality of primary care' and 'use of primary care'. The product of these two is 'use of quality primary care', which affects diagnosis and control of high blood pressure, cholesterol, and diabetes. The US estimate of quality of primary care was based on a large survey that addressed physician compliance with more than 400 different guidelines for primary care, covering preventive, chronic, and acute care.[17] There is no equivalent NZ data so the US figure of 54% was used. Similarly, the national model used the US estimate of use of primary care services (66%) which was based on data from an annual national patient survery run by CDC, the Behavioral Risk Factor Surveillance Survey.

Three parallel models − for Māori, Pacific and European/Other ethnicities − were created by using the same model structure with ethnic specific data. Initial construction and validation of the model includes empirical adjustments to causal links in the model until it accurately reflects many years of known historical data on the population stocks in the model. The model runs over the period 2000 to 2040. A number of graphs have been created to test the simulated output with known data (not shown, available on request). All three models produce a close visual fit to historical data points for diabetes, obesity, smoking and also reproduce the Census population projection. The European/Other model does not closely reproduce the recent downward trend in CVD events, possibly due to improvements in use of quality primary care.

The model predicts a lower Māori CV event rate than for Pacific and Other, which may surprise some readers. Age is the single strongest driver of CV events. We note that the age-standardised CV death rate for Māori is more than twice that of non-Māori,[18] however the rate in this model is not age-standardised as its purpose is to predict real events in a given time. Māori have a shorter life expectancy than non-Māori and an overall young population structure so constitute a considerably lower proportion of the population age 65 and over. At the 2006 Census, the ethnic proportions in those age 65 and over were: Other 93%, Pacific 2%, Māori 5%. Māori die from multiple competing causes apart from CV disease, especially respiratory conditions (Counties Manukau internal report, Gary Jackson 2009). They also have a higher fatality rate after a first CV event, therefore having few total CV events per lifetime.[19]

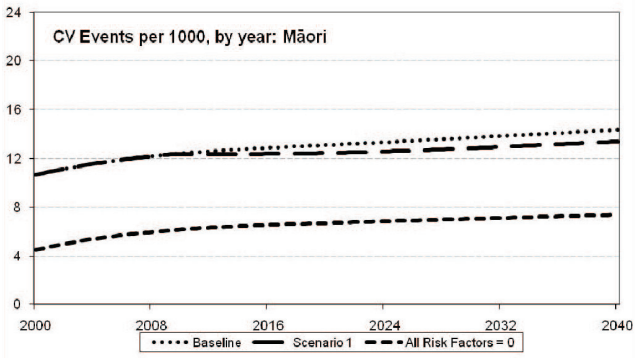
Figure 2: Examples of output from the models.

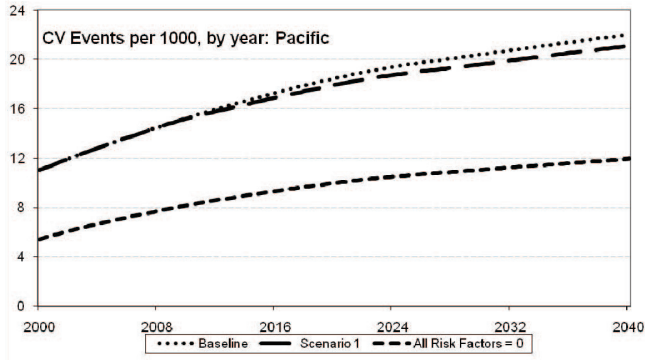
These graphs show the projected number of cardiovascular events each year, per 1000 people age 35 and over, from 2000 to 2040 in CMDHB, for Māori, Pacific and European/Other.

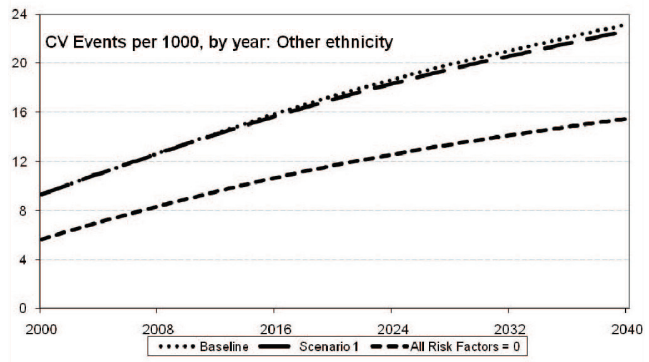
The bottom lines show the numbers if all risk factors – other than age, gender and ethnicity – are set to ideal. The top lines up to 2010 show historical trends. After 2010, the top lines are a projection of numbers if no changes are introduced. The middle lines show projected numbers if changes are introduced into the system.

For example, one scenario of anti-smoking interventions has been modelled, with the results shown below. The interventions were a 50% increase in social marketing, a 25% increase in the use of smoking cessation services and a 20% increase in the tax on cigarettes to reflect current national policy changes.

In each case the model projects a decrease in cardiovascular events, but the magnitude of decrease is most for Māori, intermediary for Pacific and least for European/Other. This difference is primarily due to a baseline smoking rates being highest in Māori, intermediary in Pacific and least in European/Other. The model therefore suggests one mechanism to reduce health inequities.







The model includes 12 interventions within five policy areas: healthy lifestyles (physical activity and diet), smoking, pollution and second hand smoke, quality and use of primary care, and mental health and stress. Each section of the model can be expanded to show more detail of variables, cause and effect, as well as displaying the data underlying the model and the sources of the data. Interactive read-only copies of the model are available on request from author David Rees at david.rees@synergia.co.nz. Lists of variables, with national and local data and annotation of data sources, are also available from authors Timothy Kenealy or David Rees.

Aims

This project aimed to take the national model and insert data specific to the Counties Manukau population, where it was available, then to assess the usefulness to CMDHB decision makers, of either the national or the locally informed model. By 'usefulness' we meant any or all of: making a difference to decisions, confirming current decisions, improving confidence with decisions made, supporting advocacy for a decision, or facilitating the process of decision making within and across different disciplines or interest groups.

Methods

Data collection

The study was conducted in three main phases, with multiple contacts and discussions with individuals continuing across the project. Roles of those consulted, and groups with whom workshops were conducted, are listed in Table 1. The work was conducted between September 2009 and May 2010. The study was approved by the Northern X Regional Ethics Committee, ref NTX/09/114/EXP.

Phase 1: We conducted an initial round of presentations to individuals and groups in CMDHB to: test initial opinions and reactions to the models; identify people and roles who considered the models potentially useful; explore what these people considered would make the models more useful; and identify sources of CMDHB data that could be used in the model instead of national data. In all, 30 participants were involved. Those involved in Phases 2 and 3 were all present in Phase 1.

Phase 2: For each data variable in the model, we sought local data, especially for population stock sizes, prevalence and incidence rates. Data were also sought from local evaluations of interventions. In some cases this required detailed re-analysis of existing data to fit the requirements of the models, especially the two age categories. This involved an iterative process of discussion with local experts and specialist clinicians, which also gave them the opportunity to explore in more detail the model assumptions and outputs. Counties Manukau data that were substituted for national data are listed in Table 2.

Phase 3: We conducted a series of presentations back to individuals and groups, a total of 14 people, asking them to consider the plausibility and usefulness of the local models in relation to their work at CMDHB.

Table 1: Individuals and groups consulted.

Phase 1 and 2 Individuals and groups consulted or interviewed (30 people)	Phase 3 workshop groups (14 people)
Cardiologist, Consultant Coronary Care Unit	Secondary care cardiology and diabetes specialists
Clinical Head of Diabetes & Endocrinology	Public Health physicians
Nurse Practitioner Coronary Care	
Primary Health Care Nurse Specialist	Planning and Funding team
Māori Health representative	Health Equity Forum
Pacific Health representative	
Mana Whenua Forum	Primary Care Team
Public Health Physicians x 3	
Self Management Facilitator	
Group Manager Health Lifestyles	
PHO Program Managers	
Program Manager Long Term Conditions	
Planning & Funding Managers	
Health Equity Forum	
Program Manager Pharmacy	

Field notes were taken in all individual and groups sessions. The final individual interviews and group sessions were audio recorded when written consent was given. The recordings were not transcribed. Author Timothy Kenealy undertook thematic analyses on the field notes and recordings, where the themes were derived from the purpose of the analysis, to determine the usefulness of the models. The results were discussed with all the other authors. Authors David Rees, Allan Moffit and Sarah Tibby had each been present at some of the interviews or group sessions. In the final sessions, individuals also provided quantitative data on a brief questionnaire asking them to nominate the portion of $10 million they would assign to each of the interventions that could be altered within the model.

Table 2:Counties Manukau data substituted in the national model.

Non-arrayed constants
Inadequate physical activity, by ethnicity
Poor diet fraction, by ethnicity and gender
Use of primary care services, by ethnicity and gender
Arrayed constants
Initial population by ethnicity, age and gender
Smoking fraction of non-CVD initial population, by ethnicity, age and gender
High blood pressure fraction of non-CVD initial population, by ethnicity, age and gender
Diabetes fraction of non-CVD initial population, by ethnicity, age and gender
Time series data
Total population turning 35, by ethnicity
Net immigration per year for population age 35+, by ethnicity
High blood pressure fraction of those age 35+, by ethnicity and gender
Diabetes fraction of those age 35+, by ethnicity and gender

Results

All participants, following explanation, were able to understand the models sufficiently to engage with them and test the implications of a range of interventions. There was little discussion or dissension about the structure of the model as such, although most participants felt that, in the NZ context, there were no interventions necessary or useful relating to the model variables 'future air pollution', 'future workplace smoking' and 'stress sources'. A question was raised about the inherent shortcomings of modelling continuous risk factors as binary, e.g. age (35-64 or 65 plus), either exercising or not, or having high blood pressure or not. This, combined with lack of empirical data on the effects of interactions between multiple variables, led some participants to an inherent scepticism in the precision of predictions from the models. Nevertheless, participants were reassured by the ability of the model to replicate known historical trends in the data. It should be noted that ongoing use of the model requires that new data is added to the historical trends and the model parameters are adjusted to reflect both the previous and the new trend data.

Participants suggested that the label 'quality of primary care provision' was potentially misleading once it was explained how this factor is constructed. The importance of the issues around primary care data is that these factors have a large impact on outputs from the models. Some participants worried that model outputs could be simplistically interpreted to support 'any' activities in primary care, including those not logically related to what the model really represents. Uncertainty over the measurement and modelling of primary care in NZ may be one of the weaknesses of the current model, and warrants further empirical research. Data from the regular NZ Health Surveys may be appropriate for the model.[20] In general, NZ primary care is more accessible than in the US, so there may be less room for improvement here.

Many participants wanted extensions to the model to include finer detail on interventions that related to their specific area of policy or clinical work. Particular interest was expressed in extensions relating to long term condition self-management, secondary-care options for patients in hospital, medication adherence support, gestational diabetes, a range of interventions to improve quality of primary care and a range of interventions to improve physical activity and diet. Given the known workload to develop and validate existing components of the model, an early decision was made not to extend the model structure (the boxes and arrows in Figure 1). Instead, the introductory explanation of the model was adjusted to emphasise the role of the models to predict the effect of, for example, a 10% improvement in primary-care quality, but not to help choose between interventions that might achieve such an improvement. With this explanation, participants accepted that if one had evidence of the effectiveness of interventions, generated external to the model, one could use the model to project the impact of such an intervention in CMDHB. Nevertheless, some participants felt that, in the absence of further detail, the main value of the current models was at a national level, where higher-level resource allocation decisions are made.

Participants recognised that the models estimated the future benefits, but not the costs, of interventions. The addition of cost data would be the single biggest component to assist in funding decisions. Although cost data is essential to making 'real life' decisions represented in the models, participants considered that cost could be provided either fully within the models or considered externally to the models. As noted, however, the CDC model includes costs modelling, and their experience is that intervention cost modelling is at least as complex as intervention benefit modelling.[13]

Several participants noted populations that were missing or invisible in the models. CMDHB has an important minority of Asian people, with subgroups that have both higher and lower CVD risks than the majority European population.[21,22]

All participants agreed that CMDHB needed to be able to incorporate local data into the model, as their population is substantively different from the national average. Indeed, this was one reason that CMDHB was keen to participate in this study. Once local data was used, however, they accepted that results were little different from the national model. They also noted that probably only the larger DHBs in the country have the resources to adapt and use such models.

Even while expressing doubts about the absolute numerical inputs and outputs for the model, all participants accepted that the main value of the outputs of the model was the ability to explore the relative magnitude of changes that could be brought about by interventions over which they had some control. An early request was made for a table with numbers to be included with the output graphs. Although this was provided, participants made little use of this detailed numerical data.

Most people in the Phase 1 presentations over-estimated the size of the impact of many interventions, particularly exercise and nutrition. On the other hand, many people underestimated the impact of smoking cessation and most were surprised by the size of effect of the primary care inputs. At the end of the workshops in Phase 3, we asked participants how they would distribute a hypothetical $10 million across the 12 policy 'levers' available in the models. The results are shown in Table 3. It should be noted that NZ already has strong legislation restricting workplace smoking. At the same time, participants also rated their agreement with a series of statements about their trust in the models and their likely use of them, shown in Table 4.

We asked participants whether they thought that modelling was more useful to help the process of work collaboration, supporting people to share their ideas and values, or whether it mainly useful for the results output from the final model. Answers made it clear that both were valuable. The process had value in itself, but even those who attribute most value to the final results were clear that, to believe these results, one had to be involved closely in the model-making process. We initially envisaged developing a web interface for the model. We decided against this, in part due to the cost, but – more importantly – because it became clear that the models could only be properly understood in the context of personal explanations. Furthermore, real value could best be achieved when the models were used within conversations and debates to which participants brought outside knowledge, values and commitment to making complex health service decisions.

Table 3: Responses to question, after Phase 3 workshops: 'If you had $10 million to spend currently to reduce CVD in Counties how would you spend it?' (n=14).

	million $: average (range)
Diet	1.1 (0, 2)
Physical activity	0.8 (0, 2)
Obesity – weight loss services	1.1 (0, 3)
Primary care – use / access	1.9 (0, 5)
Primary care – quality	1.9 (0, 5)
Tobacco – social marketing	0.5 (0, 2)
Tobacco – tax and sales restriction	1.1 (0, 5)
Tobacco – quit services	0.9 (0, 2)
Stress – decreasing sources	0.3 (0, 2)
Stress – mental health services	0.3 (0, 2)
Air pollution – general	0.1 (0, 1)
Air pollution – workplace smoking	0.1 (0, 1)
Total	$10 million

Several people reflected on their experiences with related SD models, which gave them some confidence in the potential usefulness of the current model. The impacts they cited varied between projects and included giving some objectivity to an otherwise politically sensitive discussion, persuading senior financial managers to accept a relatively long time frame for return on investment in long-term conditions, and reassuring staff that proposed workflow changes could be achieved without increasing their workload. Participants sharing these stories gave others insights into ways in which the current models might be useful rather than burdensome in their own work. Participants also recognised that the models could be useful for monitoring implementation and for evaluation of implementation of any health service changes.

Conclusions

The models generated lively interest and discussion with a wide range of policy-makers and clinicians at CMDHB. While most participants felt reluctant to use detailed output from the models in their current form, users could allow for the limitations of the models and use them to qualitatively compare decision options. All expected such models to be part of their future work, and expected them to become more valuable over time. Since this work was undertaken, refinements have been made to present the models in a more 'user friendly' manner to the CMDHB personnel. This serves to emphasise the fact that the model use and production are both ongoing processes.

Table 4: Likely use of models. Numbers of people assigning each score after Phase 3 workshops (1 'Not at all' to 5 'Absolutely') (n=14).

Score	1	2	3	4	5
Do you believe the model results?		3	5	6	
Would it help you make decisions / confirm decisions?		1	8	4	1
Would it help you to argue / advocate a decision?			9	4	1
We need Counties models, national models won't do	1	1	4	5	3
How likely are you to use these models?		4	5	5	
How likely are to you use a model modified as you want it?		3	4	7	

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References

1. Curtis E, Harwood M, Riddell T, Robson B, Harris R, Mills C, et al. Access and society as determinants of ischaemic heart disease in indigenous populations. *Heart Lung Circ.* 2010;19(5-6):316-24.
2. Hay D. Cardiovascular Disease in New Zealand, 2004: A Summary of Recent Statistical Information. Auckland (NZ): National Heart Foundation; 2004.
3. Jackson R, Lawes CM, Bennett DA, Milne RJ, Rodgers A. Treatment with drugs to lower blood pressure and blood cholesterol based on an individual's absolute cardiovascular risk. *Lancet.* 2005;365:334-41.
4. Berkman LF, Kawachi I. *Social Epidemiology*. New York (NY): Oxford University Press; 2000.
5. Commission on Social Determinants of Health. *Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health.* [Final Report]. Geneva (CHE): World Health Organization; 2008.
6. Clinton J, McNeill R, Broadbent R, Appleton-Dyer S, Leeson H, Brown P. *Overview of the Let's Beat Diabetes Evaluation 2009*. Final Report [Internet]. Auckland (NZ): Auckland UniServices, University Of Auckland; 2009 [Cited 2011 Dec 12]. Available from: http://www.betterfuture.co.nz/file/letsbeatdiabetes/SoPH-Evaluations/2009/1.-lbd-overview-report-2009-final.pdf
7. Forrester JW. *Industrial Dynamics*. Portland (OR): Productivity Press; 1961.
8. Dangerfield BC. System dynamics applications to European health care issues. *Journal of the Operational Research Society.* 1999;50:345-53.
9. Homer J, Hirsch G. System Dynamics Modeling for Public Health: Background and Opportunities. *Am J Public Health.* 2006;96(3):452-8.
10. Rees D, Orr-Walker DB. System Dynamics Modelling as a Tool in Healthcare Planning. *Proceedings of the 24th International System Dynamics Conference;* 2006 Jul 23-27; Njeimegen, Netherlands, 2006.
11. Tobias M, Cavana R, Bloomfield A. Application of a system dynamics model to inform investment in smoking cessation services in New Zealand. *Am J Public Health.* 2010;100(7):1274-81.
12. Homer J, Milstein B, Wile K, Pratibhu P, Farris R, Orenstein D. Modeling the Local Dynamics of Cardiovascular Health: Risk Factors, Context and Capacity. *Prev Chronic Dis.* 2008;5(2):1-6.
13. Homer J, Milstein B, Wile K, Trogdon J, Huang P, Labarthe D, et al. Simulating and Evaluating Local Interventions to Improve Cardiovascular Health. *Prev Chronic Dis.* 2010;7(1):1-11.
14. New Zealand Guidelines Group. *New Zealand Cardiovascular Guidelines Handbook. A Summary Resource for Primary Care Practitioners*. Wellington (NZ): NZGG; 2009.
15. Anderson K, Odell P, Wilson P, Kannel W. Cardiovascular disease risk profiles. *Am Heart J.* 1990;121:293-8.
16. D'Agostino RB, Russell MW, Huse DM, Ellison RC, Silbershatz H, Wilson PW, et al. Primary and subsequent coronary risk appraisal: New results from the Framingham study. *Am Heart J.* 2000;139(2 part 1):272-81.
17. McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of health care delivered to adults in the United States. *N Engl J Med.* 2003;348(26):2635-45.
18. Ministry of Health. *Tatau Kahukura: Māori Health Chart Book 2010*. 2nd ed. Wellington (NZ): Government of New Zealand; 2010.
19. Bramley D, Riddell T, Crengle S, Curtis E, Harwood M, Nehua D, et al. A call to action on Māori cardiovascular health. *N Z Med J* [Internet]. 2004;117(1197). PubMed PMID: 15326510.
20. Ministry of Health. *A Portrait of Health. Key Results of the 2006/07 New Zealand Health Survey*. Wellington (NZ): Government of New Zealand; 2008 [Cited 2011 Dec 12]. Available from: http://www.health.govt.nz/publications/portrait-health-key-results-2006-07-new-zealand-health-survey
21. Kenealy T, Elley C, Robinson E, Bramley D, Drury P, Kerse N, et al. An association between ethnicity and cardiovascular outcomes for people with type 2 diabetes in New Zealand. *Diabet Med.* 2008;25:1302-8.
22. Scragg R. *Asian Health in Aotearoa in 2006-2007: Trends since 2002-2003*. Auckland (NZ): Northern District Health Boards (DHB) Support Agency; 2010.