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Modelling of potential food policy interventions in Fiji and Tonga and their impacts on noncommunicable disease mortality

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ABSTRACT

Background: To compare the likely costs and benefits of a range of potential policy interventions in Fiji and Tonga targeted at diet-related noncommunicable diseases (NCDs), in order to support more evidence-based decision-making.
Method: A relatively simple and quick macro-simulation methodology was developed. Logic models were developed by local stakeholders and used to identify costs and dietary impacts of policy changes. Costs were confined to government costs, and excluded cost offsets. The best available evidence was combined with local data to model impacts on deaths from noncommunicable diseases over the lifetime of the target population. Given that the modelling necessarily entailed assumptions to compensate for gaps in data and evidence, use was made of probabilistic uncertainty analysis.
Results: Costs of implementing policy changes were generally low, with the exception of some requiring additional long-term staffing or construction activities. The most effective policy options in Fiji and Tonga targeted access to local produce and high-fat meats respectively, and were estimated to avert approximately 3% of diet-related NCD deaths in each population. Many policies had substantially lower benefits. Cost-effectiveness was higher for the low-cost policies. Similar policies produced markedly different results in the two countries.
Conclusion: Despite the crudeness of the method, the consistent modelling approach used across all the options, allowed reasonable comparisons to be made between the potential policy costs and impacts. This type of modelling can be used to support more evidence-based and informed decision-making about policy interventions and facilitate greater use of policy to achieve a reduction in NCDs.

Introduction

The major causes of death globally are noncommunicable diseases (NCDs) which include heart disease, diabetes, stroke and cancer (WHO, 2005). One of the major risk factors for NCDs is an unhealthy diet, high in fat, sugar and salt and low in fruits and vegetables (WHO, 2004).

Unhealthy food environments limit the impact of other measures to improve diets (Worsley, 2002) and so supportive environments, where individuals have the option to make healthy choices (Lawrence and Yeatman, 2008; Magnusson and Colagiuri, 2008) must be developed. Policy-based approaches offer the most powerful tools to change the food environment (Milio, 1990; World Bank, 2006; Adeyi et al., 2007), in that they can radically change food availability and access, and so change diets (Lang and Rayner, 2007).

In the Pacific Islands, NCDs are occurring at epidemic rates (Hughes and Lawrence, 2005), associated with changing lifestyles, including significant dietary changes. There is declining food self-sufficiency, and increased availability of food energy and fat/oil (Hughes, 2003).

One challenge in using policy-based interventions to improve food environments is to determine what action to take. Which policy interventions should be utilised? The World Cancer Research Fund (World Cancer Research Fund/American Institute for Cancer Research 2009), in their recommendations about policy and action, stated that "*Changes and developments in public policies and programmes have costs and possible harms as well as benefits. . . . Proposals for new policies and actions need to be based on sustained evidence of need and on the best evidence of critical problems and effective solutions.*"

In this article we present research that was undertaken to identify which policy interventions would be the most effective and

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cost-effective in supporting healthy eating in two Pacific Island countries, Fiji and Tonga. A standardised, evidence-based modelling process was used to identify the costs and benefits associated with each policy option. The approach developed was rapid and simple, in keeping with the objectives of the overall project. The modelling enabled quantitative comparisons of alternative interventions, thereby facilitating more informed decision-making by policy-makers. The purpose of this paper is to highlight the benefits of using modelling to support decision-making around policy interventions to improve diets.

Method

Research setting

This paper details a component of a research project to identify the most promising food-based policy options to control NCDs. Conducted in Fiji and Tonga, as part of the Pacific Obesity Prevention in Communities (OPIC) project, the research utilised participatory methods and an informed multi-sectoral policy advisers group (Snowdon et al., 2008, 2010a,b). The intent was that the results of the cost-effectiveness modelling would be provided to the policy advisers group to assist them in priority-setting. The data would be considered alongside assessments of side-effects (positive and negative), feasibility and effectiveness (Snowdon et al., 2010b). The policy advisers group identified 31 policy options in Fiji, and 34 in Tonga to be modelled. These included policies targeting food costs, imports, local production, access and quality. The aim of the modelling process was to determine cost-effectiveness to facilitate comparison between these policy options only, not with other projects or issues. Nor was the modelling intended to allow comparison between countries. As the results and process needed to be communicated to a multi-sectoral group, and time for analysis was limited, a clear, simple and straightforward methodology was required.

Definitions of healthier and less healthy foods were based on a nutrient profiling system (Rayner et al., 2005). Meats were classified separately according to fat content, to target only the extreme end of the fat content spectrum (high-fat meat: poultry >15%, beef >25%, pork >35%, lamb >20% and processed meat >20%). In particular these would affect mutton flaps and turkey tails.

Costs

To identify the costs associated with the delivery of each of the policy options, members of the policy advisers group were requested to develop costing pathways. These pathways detailed the processes involved in the development and implementation of each of the policies, and determined hours of staff time, and other costs involved, such as laboratory analyses for monitoring. Costing was primarily confined to direct costs to government (with a limited societal perspective); indirect costs, cost offsets or potential health-care costs associated with changes in morbidity and mortality profiles were excluded. All costs were calculated for the 2006 reference year, in the local currencies Fiji dollar (FJD) and Tongan Pa'anga (TOP). Costs were assessed and reported separately for the first year of implementation (including development costs), and for subsequent typical recurrent years, including maintenance costs.

Outcomes

Due to inadequate morbidity data for both countries, it was only possible to use deaths from NCDs as the outcome measure. The outcomes were therefore deaths averted from NCDs over the lifetime of the current adult population. Logic models (Rogers et al., 2000; Judge and Mackenzie, 2002) were developed by the policy advisers group to identify the pathways by which the policy change would lead to a change in NCD mortality. For example:

$$\text{Reduced import duty on vegetables} \rightarrow \text{reduced cost} \rightarrow \text{increased demand} \rightarrow \text{increased consumption} \rightarrow \text{reduced rates of NCDs.}$$

The effects of the policies on NCDs were mediated via changes in the intake of fats, sodium, fruits and vegetables, fish or energy. These in turn affected the risks of cardiovascular diseases, cancer (breast, oesophageal, colorectal and gastric) and diabetes. Some of these effects were mediated through changes in body mass index (BMI). Benefits were only included when there was strong quantitative evidence from the literature of an effect. An example of a detailed outcomes pathway is shown in Fig. 3.

The best available evidence was sought from the literature to identify the risk relationship between steps in the pathways. Evidence used was graded using a standard classification system (Haby et al., 2006). Local data on demographics (Statistics Division, 2007; Fiji Islands Bureau of Statistics, 2008), mortality rates (unpublished), weights/heights (Cornelius et al., 2002; Ministry of Health Tonga, 2007; Utter et al., 2008), dietary intakes (Ministry of Health Fiji, 2007) and food supply (Statistics Department, 2006; Department of Statistics, 2007) were sourced. Food composition

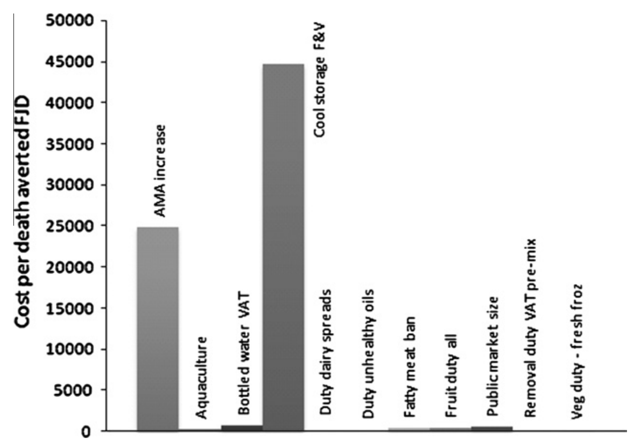

Fig. 1. Cost-effectiveness for selected policy options for Fiji. AMA, Agriculture Marketing Authority; VAT, value-added-tax; F&V, fruit and vegetables; veg duty – fresh froz, removal of import duty on fresh and frozen vegetables. At the time of writing this article, the exchange rate was 1USD = 1.85FJD.

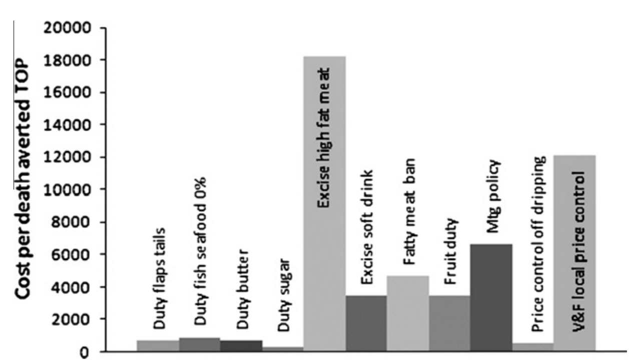

Fig. 2. Cost-effectiveness for selected policy option for Tonga. Mtg policy, Meeting and workshop food policy; V&F local price control, price control of local fruits and vegetables. At the time of writing this article, the exchange rate was: 1USD = 1.90TOP.

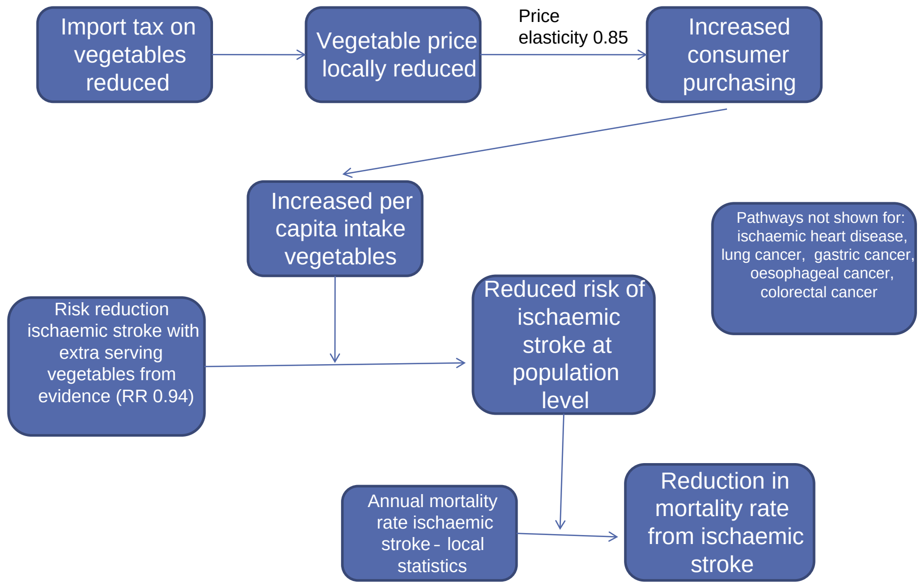

Fig. 3. Example of logic pathway for one of the modelled policy options: import tax on vegetables reduced. Further information on this pathway is provided in Appendix. RR 0.94 (Lock et al., 2004, 2005).

data was collated from relevant regional sources (Dignan et al., 2004; FSANZ, 2006). Where there were data gaps, informed assumptions were developed in discussion with the policy advisers group. In particular, an absence of price elasticity data necessitated estimates to be made to enable the modelling of price-mediated policies. Assumptions were also made regarding the wider impacts of the policies; for example, it was assumed that reductions in import duties would result in the same percentage reduction in store prices, and that higher consumption of imports would not affect intake of local vegetables. For most policies, only the effects on directly targeted foods were included, for example that a policy affecting the price of high-fat meats would affect intake of meats. Possible other effects, such as on the intake of fish were not included, due to the absence of relevant data or evidence.

Modelling was undertaken at a population (macrosimulation) level. The small number of child-centred policies highlighted within each country are not considered in this paper. The comparator was current practice. Uncertainty analysis was used to account for possible variations in data used (such as population, mortality and effectiveness data) using the '@risk' software (version 4.5 Palisade Corporation). Triangular distributions (minimum, most likely, maximum) were used, unless evidence was available that the data was normally distributed. Monte Carlo sampling was employed, with 5000 iterations run for each model. Discount rates do not usually affect rankings of interventions (Torgerson and Raftery, 1999), and as this was the main purpose of this research, the decision was made not to use discounting.

Value-for-money can be an important factor in choosing between interventions, particularly in resource-poor settings. Analysis was therefore undertaken of the cost-effectiveness (deaths averted per FJD or TOP1000 spent) and the incremental cost-effectiveness (ICER) (cost per death averted).

Further information on the method is provided in a detailed example provided in Appendix A.

Results

Due to an almost complete absence of data, four of the policy options (licensing and enforcement for roadside vendors, excise duty on fried packet snack foods, prohibition of anti-competitive licensing agreements in stores, import controls on lamb carcass fat content) could not be modelled. It should be emphasised that policies should not be compared between countries, only within countries. Differing assumptions have been used in some cases, and similar-sounding policies may also be quite different.

Costs

Costs for implementation varied widely, with many policies being very low cost to develop and maintain (Tables 1 and 2). The more costly options were those requiring additional long-term staffing (e.g. expansion of the price control system and Agriculture Marketing Authority), maintenance (e.g. provision of cool storage facilities), enforcement or monitoring (e.g. nutrient composition-based policies such as on less healthy oils). An example of costings for VAT on less healthy oils; Ministry of Health and Finance staff time to develop policy briefing (1 h and 8 h respectively), review by Minister (2 h) and Prime Minister (1 h), Environmental Health officer time each month to conduct inspections and sampling (1 h/month) and 6 laboratory analyses per month of fat types. No other additional enforcement costs.

A number of policies involved short-term additional staff time to develop policy papers. These tasks would likely be undertaken within existing staffing levels, however the costs were still included as they represent an opportunity cost (and diversion of resources from other tasks). Expected changes in revenue as a result of taxation policy options were not included in the total costs at the stakeholders' request, as it was anticipated that other measures would be implemented to ensure maintenance of taxation revenue levels. Whilst the modelling excluded these, potential losses in taxation revenue were provided to policy advisers and were considered in the discussion of implementation feasibility (Snowdon et al., 2010b).

All costs are stated in the local currencies only, Fiji Dollar (FJD) and Tongan Pa'anga (TOP). At the time of writing this article, the respective exchange rates were: 1USD = 1.85FJD, 1USD = 1.90TOP.

Benefits

The potential number of deaths averted in Tonga was lower than in Fiji, given its smaller population and hence total number of deaths (Tables 1 and 2). However, as a percentage of total

Table 1
Summary of findings from Fiji.

Policy option	Costs Fiji dollar		Deaths averted	Key area of dietary impact
	First year	Typical year	Median (95% UI)	
Reduce import duty on fresh vegetables to 0%	396	0	4.71 (1.36, 8.19)	↑ Vegetables
Reduce import duty on fresh and frozen vegetables to 0%	396	0	4.90 (1.53, 8.60)	↑ Vegetables
Reduce import duty on fresh fruits to 0%	396	0	0.77 (0.22, 1.34)	↑ Fruits
Reduce import duty on all fruits to 0%	396	0	1.16 (0.33, 2.02)	↑ Fruits
Reduce import duty on unsweetened fruits to 0%	396	0	0.86 (0.26, 1.50)	↑ Fruits
Increased role for Agriculture Marketing Authority (AMA) (to include local market access as well as export access)	801,237	800,000	32.16 (8.45, 60.77)	↑ Fruits and vegetables
Cool storage facilities to be available at all markets (to reduce wastage)	1,600,149	100,000	102.30 (48.35–175.08)	↑ Fruits and vegetables, fish
Cool storage facilities to be available for fruits and vegetables (to reduce wastage)	1,600,149	100,000	35.79 (13.53, 67.46)	↑ Fruits and vegetables
Increased public market size by 25%	40,146	20,000	82.04 (42.69, 141.01)	↑ Fruits and vegetables
Reduce import duty on all aquaculture related equipment to 0%	396	0	1.42 (0.37, 3.04)	↑ Fish
Cool storage facilities to be available for fish (to reduce wastage)	1,600,149	100,000	65.54 (18.77, 123.83)	↑ Fish
Removal import duty and VAT on pre-mix fuel for fishermen (to reduce costs of fishing)	396	0	14.18 (3.83, 30.66)	↑ Fish
Removal excise duty on local bottled water	396	0	0.78 (0.43, 1.30)	↓ Soft drinks
Removal VAT from bottled water	396	0	0.62 (0.40, 0.88)	↓ Soft drinks
Introduction of price control for bottled water	414	0	0.96 (0.55, 1.60)	↓ Soft drinks
Increase import duty on unhealthy oils to 15%	11,403	11,007	68.45 (49.43, 91.06)	Replacement unhealthy oils with healthier ones
Increase import duty on all cooking oils to 15%	396	0	17.43 (12.25, 23.87)	↓ oils
Increase import duty on unhealthy oils to 15% and for other oils to 5%	11,403	11,007	75.07 (56.23, 96.76)	Combination of above two
Increase import duty on dairy spreads to 15%	396	0	15.28 (11.13, 19.87)	Replacement with healthier spreads
Removal of concessionary import duty for meat to be processed locally (to ensure that processed meat is not cheaper than unprocessed meat)	396	0	4.31 (2.80, 6.10)	↓ Processed meat
Remove fatty meats from the price control system	6464	5870	5.55 (1.72, 9.67)	Replacement high-fat meats with leaner meats
Ban the sale of fatty meats	7170	6170	20.03 (10.90, 32.36)	Replacement high-fat meats with leaner meats
Ban the sale of fatty processed meats	7406	5197	12.22 (9.27, 15.84)	Replacement high-fat meats with leaner meats

UI, uncertainty interval; VAT, value added tax.

deaths, the results were similar in the two countries. The benefit in Fiji and Tonga of the most effective policies was also similar as a percentage of total NCD-related deaths averted (around 3%). The uncertainty intervals (95%) for deaths averted, while large for some of the policies, did not cross the no-effect line.

The effectiveness of the policies varied considerably. In Fiji, there was more than a 200-fold difference between the most and least effective options, whereas in Tonga, there was less than a 40-fold difference.

Cost-effectiveness (Tables 1 and 2 and Figs. 1 and 2

In Fiji, the development of 'cool storage facilities at all markets' was both the most effective in terms of deaths averted and the most costly intervention to implement (Table 3). It rated relatively poorly for overall cost-effectiveness. The policies which were relatively cheap to implement, such as 'import duty' changes, were the most cost-effective. The least cost-effective policies targeted bottled water use and imported fruit, neither of which was consumed in high amounts.

In Tonga, the most effective policies in terms of deaths averted targeted the consumption of fattier meats, which reflects the high current local consumption levels (Table 3). The less effective policies targeted cheese and imported fruits and vegetables, which were not heavily consumed. Price control measures were relatively costly due to the additional staffing required for monitoring. (Note that price control in both countries entails mark-ups only, and does not involve subsidies.)

The overall cost-effectiveness of most of the policy options was lower in Tonga. For example, the least cost-effective option in Tonga (price control on imported fruit) cost an estimated FJD70,000 per death averted, compared to FJD42,000 (cool storage for fruits and vegetables). Similarly the most cost-effective option per death averted in Fiji, was cheaper than that in Tonga ('duty on all oils' FJD22 versus 'roadside vending' FJD140). This was due to the higher overall projected costs for policies in Tonga compared to Fiji, related to higher labour costs in Tonga.

The five most cost-effective policies in Fiji (Table 3) were all fiscal policies, affecting import duty and value-added-tax. This reflects in part their relatively low implementation costs (excluding government revenue losses). Tonga's most cost-effective policies (Table 3) were more of a mix of instruments, affecting prices of foods and availability.

Discussion

The results of this research highlight the extensive variations in the likely impact and cost-effectiveness of different policy interventions to improve the food environment in these two countries. In the absence of this type of modelling process, the decision-making process for health promoters regarding what policy changes to target would be limited to subjective assessments of health benefit (Snowdon et al., 2010b).

The quantitative results allow an easy comparison between related policies. For example, in Tonga, the imposition of bans on high-fat meats would be substantially more effective than measures to increase their costs (and would be more cost-effective). Removing import duty on both fresh and frozen vegetables in Fiji is more cost-effective than targeting just fresh vegetables. Using consistent methods, combined with transparency about the assumptions involved and the methodological limitations, ensures that users are able to make informed judgements about which pol-

Table 2
Summary of findings from Tonga.

Policy option	Costs Tongan Pa'anga		Deaths averted	Key area of dietary impact
	First year	Typical year	Median (95% UI)	
Reduce import duty on fresh and frozen vegetables to 0%	509	0	0.26 (0.06,0.46)	↑ Vegetables
Reduce import duty on fresh fruits to 0%	509	0	0.15 (0.04, 0.27)	↑ Fruits
Imported fruits to be added to price control system	15,603	15177	0.19 (0.05, 0.38)	↑ Fruits
Imported vegetables to be added to price control system	15,603	15177	0.25 (0.06, 0.49)	↑ Vegetables
Reduce import duty on tinned fish and seafood to 10% (fresh/frozen only those not caught locally)	509	0	0.29 (0.09, 0.55)	↑ Fish
Reduce import duty tinned fish and seafood to 0% (fresh/frozen only those not caught locally)	509	0	0.58 (0.18, 1.09)	↑ Fish
Reduce import duty tinned fish to 0%	509	0	0.46 (0.14, 0.88)	↑ Fish
Add imported seafood to price control list	15603	15177	0.26 (0.08, 0.49)	↑ Fish
Add tinned fish to price control list	15603	15177	0.46 (0.14, 0.88)	↑ Fish
Removing license requirement for roadside vendors selling local fresh produce (uncooked, unprocessed) (to increase number of vendors)	0	0	1.31 (0.33, 2.76)	↑ Fish, fruits and vegetables
Introduce 15% excise duty for soft drinks (all sweetened drinks, including milk)	1595	0	0.34 (0.21, 0.52)	↓ Soft drinks
Introduction of price control for bottled water	15603	15177	0.26 (0.14, 0.41)	↓ Soft drinks
Reduce import duty from 15% to 0% for margarine	509	0	0.21 (0.12, 0.32)	Replacement of less healthy spreads
Remove dripping from price control list	426	0	0.85 (0.46, 1.27)	Replacement with healthier fats
Remove unhealthy oils from price control list	20990	20564	2.31 (1.42, 3.21)	Replacement with healthier oils
Increase import duty from 0% to 15% for butter	509	0	0.74 (0.44, 1.09)	Replacement with healthier fats
Introduce excise duty of 15% for dripping and other animal fats	1595	0	0.88 (0.48, 1.27)	Replacement with healthier fats
Reintroduce 15% import duty for high-fat meat and poultry (mutton flaps and turkey tails)	509	0	0.77 (0.53, 1.10)	Replacement high-fat meats with leaner meats
Increase import duty corned beef/mutton from 0% to 15%	509	0	0.93 (0.57–1.36)	Replacement high-fat meats with leaner meats
Introduce 15% excise duty for high fat meat/poultry	15655	13416	0.86 (0.60, 1.21)	Replacement high-fat meats with leaner meats
Introduce 15% excise duty for corned beef/mutton	1595	0	0.93 (0.57, 1.36)	Replacement high-fat meats with leaner meats
Introduce 15% excise duty for mutton flaps	1595	0	0.47 (0.28, 0.73)	Replacement high-fat meats with leaner meats
Introduce 50% excise duty for turkey tails	1595	0	0.99 (0.70, 1.3)	Replacement high-fat meats with leaner meats
Sales ban on high-fat meats	30974	13436	6.61 (4.67, 9.02)	Replacement with lower-fat meats
Regulation that processed meats sold contain no more than 20% fat	30974	13436	0.41 (0.21, 0.70)	Replacement with lower-fat meats
Price control healthier meats	44526	28947	2.35 (1.40, 3.65)	Replacement of higher-fat meats with healthier ones
Introduce 30% excise duty for confectionary	1595	0	1.27 (0.79, 1.90)	↓ Confectionary
Increase import duty from 0% to 15% for sugar	509	0	1.92 (1.45, 2.45)	↓ Intake
Mandatory government workplace food policy	6135	0	0.93 (0.14, 1.93)	Healthier diets amongst government employees (↑ fruits and vegetables)
Remove cheese from price control list	426	0	0.14 (0.08, 0.23)	↓ Intake, replacement with lean meat or fish

UI, uncertainty interval.

icy options offer better outcomes in terms of reducing deaths from NCDs.

The stakeholders involved in the process expressed considerable interest in the results, and also in the data used. The results of the modelling did alter the decision-making by the stakeholders when the prioritisation of policy options was undertaken. It resulted in some options being prioritised for action, which were not previously identified as important. For some policy options, the results of the modelling had less effect, particularly for policies which were considered to be linked with preventing future problems (such as vending machines in schools), rather than dealing with existing ones. In many instances, stakeholders were not previously aware of the data being sourced. Assumptions and requests made by the stakeholders had considerable impact on the results, for example the request to exclude tax revenue in Tonga. The final part of this modelling process was a workshop session to discuss findings with stakeholders and ensure they fully understood the limitations and assumptions of the models, prior to prioritising policies for action. Since the implementation of this research, many of the policy options have been incorporated into National Strategies for diets and NCDs, and some of the specific policy options are in progress, although this action may or may not be related to the findings of this research.

It should be noted that the results of the modelling for individual policy changes are not additive, and that joint costs and benefits have not been considered. For example, changing the import duty rate on several items, would incur almost the same cost as changing the duty on just one item. Likewise, the benefits are not directly additive, particularly for overlapping policies. For example, reducing import duty on seafood to 10% or 0% - these cannot both be implemented as they are alternative approaches. Some of the modelling results could be combined; for example, the four most cost-effective policy options in Fiji would be unlikely to overlap in terms of foods affected, and could avert 56 deaths. These may be under or over-estimates depending upon interactions between policies.

Implementing policy approaches to improve diets is important in efforts to control NCDs. The modelled benefits of individual policies may look small, but should be considered in terms of overall mortality rates in Fiji and Tonga. Deaths from diet-related noncommunicable diseases (WHO, 2003) in Fiji in 2006 were 3147. The most effective policy intervention (cool storage at all markets) could avert 3% of these deaths. In Tonga, average annual deaths from diet-related noncommunicable diseases (2002–2006) were 213. The most effective policy (ban on the sale of high-fat meats) was modelled to prevent 3% of these deaths. These represent significant benefits; for example if the US was able to avert 3% of its annual noncommunicable deaths, this would equate to around 51,000 deaths (Centers for Disease Control and Prevention, 2004).

The effectiveness of similar policy options was different for the two countries, and reflected differences in food supply, diets, pricing structures etc. This indicates the importance of undertaking

Table 3
Ranking of policy options in Fiji and Tonga.

Fiji					Tonga				
Most effective policy options	Least effective policy options	Most costly in first year	Lowest costs (first year costs) per death averted	Highest costs (first year costs) per death averted	Most effective policy options	Least effective policy options	Most costly in first year	Lowest costs (first year costs) per death averted	Highest costs (first year costs) per death averted
1. Cool storage available at all markets	1. VAT removed from bottled water	1. Cool storage available at all markets	1. Import duty (15%) added to all oils	1. Cool storage for fruits and vegetables	1. Ban on sale of all fatty meats (including processed)	1. Price control removed for cheese	1. Price control only for healthier meats	1. Removal licensing requirement for roadside vendors selling local produce	1. Price control for (imported) fruit
2. Public market size increased by 25%	2. School drink vending policy	Cool storage for fruits and vegetables	2. Import duty (15%) added to dairy spreads	2. AMA role expanded to cover local markets	2. Ban on sale of fatty unprocessed meats	2. Import duty on all fruit reduced to 0%	2. Ban on sale of fatty unprocessed meats	2. Import duty on sugar increased to 15%	2. Ban on sale of fatty processed meats
3. Import duty added to unhealthy (15%) and all oils (5%)	3. Import duty on all fresh fruit reduced to 0%	Cool storage facilities available for fish	3. Removal of duty and VAT on fuel for fishermen	3. Cool storage available at all markets	3. Price control for healthier meats	3. Price control for (imported) fruit	2. Ban on sale of all fatty meats (including processed)	3. Fuel subsidy provided for fishermen	3. Price control for (imported) vegetables
4. VAT or 15% duty added to unhealthy oils only	4. Excise duty removed from bottled water	4. AMA role expanded to cover local markets	4. Import duty on fresh and frozen vegetables reduced to 0%	4. Cool storage facilities available for fish	4. Price control removed for unhealthy oils	4. Import duty on margarine reduced to 0%	2. Ban on sale of fatty processed meats	4. Price control removed from dripping	4. Price control for (imported) seafood
5. Cool storage facilities available for fish	5. Import duty on all unsweetened fruit reduced to 0%	5. Public market size increased by 25%	5. Import duty on fresh vegetables reduced to 0%	5. Price control removed from fatty meats	5. Import duty on sugar increased to 15%	5. Price control for (imported) vegetables	5. Price control removed from unhealthy oils	5. Import duty on all animal fats increased to 15%	5. Price control for (bottled) water

VAT, value added tax (12.5%); AMA, Agriculture Marketing Authority.

this type of assessment at a country-specific level, and not relying on the translation of results obtained in another jurisdiction. Fiji and Tonga while sharing some similarities, are markedly different in terms of many factors including ethnic diversity, population size, geography, social structures and health profiles. Other countries may also have substantially different mortality patterns which will also impact on the results. Food supply, diet and mortality patterns will change over time, and the process would need to be repeated if the implementation of the policies was considerably delayed.

This research has also demonstrated that many policy interventions are relatively low cost to prevent, particularly in comparison to treatment costs for NCDs which are extremely high, even in the Pacific Islands (Doran, 2003; Khaleghian, 2003). Additionally the costs would be borne by government departments other than the Ministry of Health for many of the policies. The cost burden falling on any one government department would not be particularly onerous.

It is acknowledged that this modelling has considerable limitations, linked both to its design and the data used. This is a relatively crude form of modelling, which does not include variations between population sub-groups and is based solely on averages. However, this type of method has been used elsewhere (Joffe and Robertson, 2001; Mytton et al., 2007; Lloyd-Williams et al., 2008), and can provide reasonable estimates, particularly for the purpose of ranking interventions. The use of this type of modelling is preferable to the existing situation, where policies are made without the use of evidence and without regard to potential health benefits.

Discounting was not used in this research, which could lead to false assumptions being made about the relative value-for-money of the interventions. The exclusion of discounting was in line with the project's aim of finding a relatively simple, rapid and reliable way to assess cost-effectiveness, and made the method and results easier to explain to the policy advisers group. Additionally as all policies were targeted at NCDs in adults, time-frame for benefits and costs to accrue are likely to be similar. The aim was to enable comparisons between the policy options modelled, and discounting is unlikely to have had significant effects on this.

The modelling assumed that policies were working at their maximum effectiveness and were maintained long-term, with no transitional periods. It was not possible to include cross price-elasticities or other effects of policy changes on non-targeted foods, due to an absence of data. This omission may lead to modelled benefits being under or over-estimates.

The quality of the evidence used was generally high, particularly for effects of dietary change on NCDs. For the effects of the policies, however, lower grade evidence had to be used (for example, for the effects of workplace food policy). It was not possible to source evidence specifically from the Pacific Island region, and risk relationships may differ locally.

Limited availability of local data caused some difficulties. Food supply data used may have overestimated intake (Pomerleau et al., 2003), particularly in Fiji where allowance could not be made for re-exports. Mortality data used is likely to be incomplete (Taylor et al., 2005; Hufanga and Bennett, 2007) and it was not possible to incorporate future trends in disease mortality or population demographic. It would have been preferable to have modelled morbidity and mortality, to account for the considerable morbidity burdens associated with NCDs, but incidence or prevalence data was not available. The absence of morbidity assessments from the modelling considerably underestimates benefits, as NCDs are chronic diseases which can affect the health and productivity of individuals for decades prior to causing mortality. There are however differences in mortality and morbidity profiles for different conditions; for example where some forms of cancer are fatal within a short period of time compared to others. This means that mortality patterns are not directly correlated with morbidity patterns.

Conclusion

Overall, despite the limitations of the methodology, this research provided the first opportunity for policy advisers to make policy recommendations informed by evidence. The research has highlighted the considerable range of potential benefits and costs arising from food policy changes. In the absence of the modelling, policy advisers would be unable to incorporate effectiveness and cost-effectiveness within their decision-making process. This is the first time that a series of policies, from across a range of government departments, have been evaluated in terms of health outcomes, using a consistent methodology. The comparisons of cost-effectiveness for policy interventions did influence their recommendations, highlighting benefits of policies which had not been seriously considered previously. While a low cost-effectiveness did not always prevent a policy from being recommended, policies which were expected to be highly effective were more likely to be prioritised. This relatively simple and low cost analysis provided useful information for decision-making, and could be communicated to them without difficulty. Additionally the modelling results will be utilised in advocacy for policy change.

Decisions about policy change to improve health need to be based on a consideration of evidence, along with other relevant factors such as feasibility and acceptability (Snowdon et al., 2010b). Other countries should consider undertaking similar assessments prior to recommending policy change, particularly in regard to complex issues like diets. Those with greater resources and data access can develop a more sophisticated method in the areas discussed, to enhance its quality.

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Appendix A. Details of modelling of 'reduced import duty on fresh vegetables' for Fiji

The policy option to reduce import duty on vegetables was intended to lead to reduced vegetable prices for consumers, resulting in higher intakes of vegetables and in turn reduced risks of some non-communicable diseases (Fig. 3). In this appendix, further details are provided to indicate the modelling process for the costs and benefits of this policy option.

A.1. Costs

The development of costings was based on feedback and suggestions from stakeholder group members, the co-researcher and local counterpart. The process for revision of import tariffs was identified as follows:

- Step one: A brief discussion and justification paper be prepared by the Ministry of Finance (one working day) with support from Ministry of Health (1 h).
- Step two: This paper be passed on to the Minister for consideration and endorsement (2 h of the Minister's time).
- Step three: The endorsed paper be passed on to the Prime Minister for consideration and endorsement (1 h of the Prime Minister's time).
- Step four: Internal communications are then sent to the implementing agency, and messages posted on relevant websites to communicate changes to relevant stakeholders. (No costs incorporated.)

The existing legislation on import duties permits that modifications to tariff rates can be made by the Minister of Finance.

Approximate official salary costs were sourced from stakeholders. Staffing for step one was costed at senior officer level. These salaries were used to calculate the overall costs for development of the legislation. Only core-costs were included; costs such as offices, electricity or other add-ons were excluded due to lack of information. Costing was based on one policy being implemented at a time. No implementation or enforcement costs were included as the variation to an existing tariff rate would not require any additional implementation costs to those already being used.

The overall implementation cost was calculated to be FJD396. This clearly represents a minimal estimate, however, it is likely that no additional staff would be recruited for this work, and the costs would therefore be absorbed within existing workloads.

The calculation of expected revenue losses from the removal of import duty was based on latest available import statistics (Fiji Islands Bureau of Statistics 2007), which were for 2006. These report imports of vegetable types by weight (tonne) and value (FJD). At the time, the import duties for vegetables were either 0% (e.g. onions), 5% (e.g. carrots) or 27% (e.g. cauliflower). The detailed tariff schedule was used to identify imports of vegetables in 2006 which had import tariffs of 5% or 27% applied. The reported cost of these imported vegetables (Fiji Islands Bureau of Statistics 2007) was used to calculate the income expected from the 5% and 27% import tariff. The total was FJD2 032 934. The potential future revenue losses were not calculated, as the intent was to compare revenue changes to 2006.

A.2. Benefits

The logic pathway for the benefits of this policy option was that the removal of the import tariff would lower costs to consumers, meaning that they would purchase and consume more, and that their risk of non-communicable diseases would be reduced. Each of these steps in the model is detailed below.

A.2.1. Step one: calculation of current consumption

The total quantity of vegetables imported in 2006 for both the 5% and 27% tariff band was calculated (253,000 kg and 3,503,000 kg respectively). Based on international guidelines (FAO/WHO/UNU 2004) and population demographics (Fiji Islands Bureau of Statistics, 2008), the expected proportion of total dietary energy supply which would be consumed by adults was calculated to be 60%. This assumes that all sectors of the population under or over consume at the same rates. Assuming that the intake of vegetables is correlated with intake of dietary energy, it was estimated that 60% of the vegetable supply imported was consumed by adults.

By dividing the quantities of the vegetables in each of the two tariff bands by the Fiji adult population 474,155 (Fiji Islands Bureau of Statistics, 2008), and using the 60% assumption, consumption in the reference year was calculated as 0.96 g and 13.3 g of vegetables per adult per day, from the 5% and 27% tariff bands respectively.

A.2.2. Step two: calculation of dietary changes expected

The following assumptions were made: that all price changes would be fully passed onto the consumer, that only one food price would change at once and that no other significant price or income changes occurred in Fiji at that time.

The percentage price reduction for the vegetables affected by the removal of 27% import tariff was calculated as:

$$(1/1.27) \times 100 = 21.3\%$$

For vegetables affected by the removal of 5% tariff, the price reduction was calculated similarly to be 4.8%.

Price elasticity data were also needed for this stage of the modelling. A literature search identified data for Fiji for fruits and vegetables of 0.43 (Seale et al., 2003) and 1.6 for bele (a local green leafy vegetable) (Hone and Haszler, 2007). The markedly different values may be due to different methods, timing of assessment and the foods involved. Discussions with stakeholders identified that imported vegetables were valued more than local ones, and so purchasing was not solely influenced by pricing. A price elasticity range of 0.7–1 was therefore assigned (this indicates that a change in price leads to slightly less than proportionate change in demand). The inclusion of ranges or confidence intervals is feasible in modelling when using software such as @risk. From hereon in this appendix, it should be noted that calculated values are indicative only, as the final values were calculated only for modelled outcomes (deaths averted).

The following calculations were conducted within the Excel spreadsheet:

Adult intake/day of vegetables[#] x price elasticity x expected % reduction in cost

[#] Note that the above calculation was done for the vegetables affected by the 27% tariff and then separately for those affected by the 5% tariff.

The overall expected increase in vegetable intake per capita from the removal of the two tariffs was 3.4 g per day.

A.2.3. Step three: Calculation of effects on mortality

For this model, it was assumed that increases in vegetable intake would not affect total calories. This assumption was necessitated by uncertainty and lack of data regarding possible other dietary changes due to increased vegetable intake.

The evidence for the impact of increased vegetable intake on the risk of mortality from specific diseases was sourced from a recent review and meta-analysis (Lock et al., 2004, 2005). These sources provided the effects of fruit and vegetables expressed as relative risk estimates associated with an 80 g/day increase in fruit and vegetable intake.

- Gastric cancer: 0.94 (0.86, 1.03).
- Lung cancer: 0.96 (0.93, 0.99).
- Colorectal cancer: 0.99 (0.97, 1.02).
- Oesophageal cancer: 0.94 (0.88, 1.01).
- Iscahemic heart disease: 0.9 (0.82, 0.99).
- Ischaemic stroke: 0.94 (0.89, 0.99).

Mortality from the above causes was sourced from available statistics (Ministry of Health, Fiji, unpublished). For both ischemic stroke and ischemic heart disease, there was some uncertainty regarding the use of some ICD (International Classification of Disease) codes; in which necessitated the following uncertainty ranges being included around the mortality estimates. Ischemic stroke 333–359, ischemic heart disease 649–924, lung cancer 39, gastric cancer 23, oesophageal cancer 10 and colorectal cancer 31.

The following calculation was then applied for each disease category

(Expected change in vegetable consumption per capita per day $\div$ 80) $\times$ mortality for disease in a year $\times$ (1-relative risk)

For example, for oesophageal cancer:

$$= (3.4/80) \times 10 \times (1 - 0.94) = 0.03$$

Combining the expected deaths averted per category, and using @risk to model uncertainties, the result for this policy was 4.71, with an uncertainty range of 1.36–8.19.

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