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Applications of nutrient profiling: potential role in diet-related chronic disease prevention and the feasibility of a core nutrient-profiling system

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Background/objectives: A number of different nutrient-profiling models have been proposed and several applications of nutrient profiling have been identified. This paper outlines the potential role of nutrient-profiling applications in the prevention of diet-related chronic disease (DRCD), and considers the feasibility of a core nutrient-profiling system, which could be modified for purpose, to underpin the multiple potential applications in a particular country.

Methods: The ‘Four P’s of Marketing’ (Product, Promotion, Place and Price) are used as a framework for identifying and for classifying potential applications of nutrient profiling. A logic pathway is then presented that can be used to gauge the potential impact of nutrient-profiling interventions on changes in behaviour, changes in diet and, ultimately, changes in DRCD outcomes. The feasibility of a core nutrient-profiling system is assessed by examining the implications of different model design decisions and their suitability to different purposes.

Results and conclusions: There is substantial scope to use nutrient profiling as part of the policies for the prevention of DRCD. A core nutrient-profiling system underpinning the various applications is likely to reduce discrepancies and minimise the confusion for regulators, manufacturers and consumers. It seems feasible that common elements, such as a standard scoring method, a core set of nutrients and food components, and defined food categories, could be incorporated as part of a core system, with additional application-specific criteria applying. However, in developing and in implementing such a system, several country-specific contextual and technical factors would need to be balanced.

Keywords: nutrient profiling; diet-related chronic disease; applications

Background

Nutrient profiling is commonly defined as ‘the science of categorising foods according to their nutritional composition’ (O’Neill, 2004; Rayner et al., 2005; Townsend, 2010). Nutrient profiling is typically used to categorise foods (using words, graphics or numbers) according to either the nutrient levels in the food (for example, ‘high fat’, ‘low fat’, ‘source of fibre’, ‘energy dense and nutrient poor’) or with respect to the effects of consuming the food on a person’s health (for example, ‘healthy’, ‘healthier option’, ‘less healthy’, ‘good for your heart’). These categorisations can form an important part of policies aimed at improving public health nutrition and preventing diet-related chronic disease (DRCD) (Rayner et al., 2004).

Nutrient profiling is currently being used as part of a number of nutrition policy applications around the world, and the number of different nutrient-profiling models has increased rapidly in recent years (Stockley et al., 2008). The most common use of nutrient profiling is in nutrition signposting schemes aimed at assisting consumers to make healthier food choices. Such schemes have been devised by governments (for example, the Swedish National Food Administration’s ‘Keyhole’ scheme (Larsson and Lissner, 1996; Swedish National Food Administration, 2009)), non-governmental organisations (for example, the National...
Heart Foundation of Australia’s ‘Pick-the-Tick’ scheme (National Heart Foundation of Australia, 2008)) and multi-stakeholder groups (for example, the United States ‘Smart Choices’ programme (Smart Choices Program, 2010) (now discontinued)). Many governments around the world (for example, Australia and New Zealand (Food Standards Australia New Zealand, 2008) and the European Union (European Food Safety Authority, 2010)) have also used, or propose to use, nutrient profiling in the regulation of nutrition and health claims. Furthermore, the United Kingdom Office of Communications base their restrictions on television advertising of food and drink products to children on the nutrient-profiling model developed by the UK Food Standards Agency (Office of Communications United Kingdom, 2007b), and products available for sale in schools often rely on a nutrient-profiling model to determine foods eligible for sale (for example, the Australian Health School Canteens Guidelines (NSW Department of Health and NSW Department of Education and Training, 2006)).

As governments seek to develop comprehensive, multi-pronged strategies for the prevention of DRCD and obesity in particular (World Health Organization, 2008; Sacks et al., 2009), it will be increasingly important that policy interventions are complementary in both their design and impact. With multiple potential applications of nutrient profiling and the increasing number of different nutrient-profiling models globally, there are risks of unnecessary duplication, discrepancies between models, and confusion for regulators, manufacturers and consumers. For example, without due care, the nutrient-profiling model developed for one application may contradict the nutrient-profiling model developed for another application. The aims of this paper are to identify the potential role of nutrient-profiling applications in the prevention of DRCD and consider the feasibility of using a common nutrient-profiling system to underpin the multiple potential applications. Such a system, defined here as a ‘core nutrient-profiling system’, would have some, but not necessarily all, design elements and structures that are used consistently across all applications.

The structure of the paper is as follows. First, a framework for identifying and classifying the potential applications of nutrient profiling is proposed. A logic pathway is then presented that can be used to evaluate the potential impact of nutrient-profiling interventions on DRCD and to validate the effectiveness of nutrient-profiling models. The implications of different nutrient profiling-model design decisions and their suitability to different applications are then discussed, and the feasibility of a core system examined.

There are many aspects to nutrient profiling and this paper does not attempt to address all the issues that are currently the subject of considerable debate. In particular, it does not seek to consider in detail the process of developing a nutrient-profiling model or the different methods for validating models (as distinct from evaluating nutrient-profiling interventions). These issues are dealt with in many of the references to this paper and elsewhere.

### Framework for identifying and classifying potential applications of nutrient profiling

Several authors have identified multiple potential applications of nutrient profiling (Stockley et al., 2008; Lobstein and Davies, 2009; Townsend, 2010); however, the lists generated by these authors do not necessarily reflect a systematic approach. To assist researchers and policy makers to identify and classify potential applications in a comprehensive and systematic way, a classification framework is warranted. This can help to ensure that consideration is given to all the potential uses of a model during its development and subsequently.

One of the objectives of public health nutrition policy is to shift population towards healthier diets through changes in the food environment and, ultimately, in eating behaviour. Consequently, insights from marketing, which is centred on strategies to influence behaviour, are likely to be valuable. Indeed, marketing principles are increasingly used in public health interventions (Rayner, 2007; French et al., 2009). With this in mind, it is proposed that the potential applications of nutrient profiling can be categorised using the ‘Four ‘P’s of Marketing’ (Product, Promotion, Place and Price), originally proposed in 1960 (McCarthy, 1960). Examples of potential applications of nutrient profiling, classified using the ‘Four ‘P’s’ framework are shown in Table 1.

In relation to the ‘Product’ dimension, nutrient profiling can help to decide which products should or should not be fortified, and it can provide standards and guidelines for product formulation and re-formulation. From a ‘Promotion’ perspective, nutrient profiling can be used to regulate and set guidelines for commercial marketing to consumers. It can

#### Table 1 Potential applications of nutrient profiling classified using the ‘Four ‘P’s of Marketing’ framework, based on examples previously identified (Stockley et al., 2008; Lobstein and Davies, 2009; Townsend, 2010)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Potential application of nutrient profiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Compositional standards for specific foods.</td>
</tr>
<tr>
<td></td>
<td>● Product reformulation targets and guidelines</td>
</tr>
<tr>
<td></td>
<td>● Restrictions on product fortification</td>
</tr>
<tr>
<td>Promotion</td>
<td>● Regulation of health and nutrition claims</td>
</tr>
<tr>
<td></td>
<td>● Food labelling (regulations, voluntary schemes and health-related endorsements)</td>
</tr>
<tr>
<td></td>
<td>● Menu labeling</td>
</tr>
<tr>
<td></td>
<td>● Marketing and advertising regulations</td>
</tr>
<tr>
<td></td>
<td>● Social marketing campaigns</td>
</tr>
<tr>
<td>Place</td>
<td>Standards for food procurement (public and private)</td>
</tr>
<tr>
<td></td>
<td>● Standards for food provision (schools, hospitals, other organisations) including vending and fund raising</td>
</tr>
<tr>
<td></td>
<td>● Import regulations (based on nutrient standards of particular foods)</td>
</tr>
<tr>
<td>Price</td>
<td>Taxes and subsidies for producers, manufacturers, retailers and consumers</td>
</tr>
<tr>
<td></td>
<td>● Government food subsidies for vulnerable groups for example, people on a low income</td>
</tr>
<tr>
<td></td>
<td>● Price-based promotions by manufacturers and retailers</td>
</tr>
</tbody>
</table>
also be used in motivating individuals to adopt healthier diets through, for example, social marketing that promote products that meet ‘healthier’ criteria. With regard to ‘Place’, governments are increasingly regulating the availability of certain foods in schools (both at meal times and through vending), hospitals, prisons and other public institutions. Nutrient-profiling models can help governments, and other organisations decide which foods should or should not be made available for sale and/or consumption. With respect to ‘Price’, nutrient profiling provides a method for categorising foods for taxation (or subsidy) purposes, and can also be used to assess whether retailer price reductions are in line with public health goals. Furthermore, nutrient profiling can be used as part of government food-assistance programmes to decide which foods should be subsidised and which should not be subsidised. Future applications of nutrient profiling could potentially be expanded to include rankings of meals and diets (rather than individual products), overall marketing strategies and the relative ‘healthiness’ of brands and companies.

Logic pathway for evaluating the potential impact of interventions based on nutrient profiling

Although the previous section illustrates that there are many potential applications of nutrient profiling, there is very little direct evidence of the potential impact of these type of interventions on DRCD outcomes (Townsend, 2010). In the absence of empirical effectiveness data, modelled estimates are necessary to assess the potential impact of these interventions (Carter et al., 2008). Such estimates need to be based on a logic pathway that outlines the steps by which a change in policy (such as the implementation of one of the nutrient-profiling applications) may be expected to lead progressively to changes in behaviour, changes in diet and, ultimately, changes in DRCD outcomes. Each of these intermediate and end point outcomes can also be used to validate nutrient-profiling models, both prospectively (as part of the design and/or selection of a model) and retrospectively against the specified purpose of the model.

A suggested logic pathway for estimating the effect of a change in food policy on changes in health outcomes is depicted in Figure 1, building on logic models previously described (Swinburn et al., 2006). As obesity is a major component of DRCD, and in recognition of the influence of physical activity on obesity, the logic pathway, shown in Figure 1, also includes changes in physical activity environments. Furthermore, the logic pathway identifies that policies may have effects that are not explicitly related to health outcomes—these may include economic, social and environmental impacts (Sacks et al., 2009), for example, policies promoting lower consumption of red meat may result in lower greenhouse gas emissions (McMichael et al., 2007).

The ‘Four ‘P’s’ framework is again used in the logic pathway to illustrate the way in which policy changes lead to changes in eating behaviour. It is recognised that different policies may seek to influence different determinants of consumer choice. Some policies are designed to change environments, which then lead to behaviour change (for example, a change in taxes may result in a change in consumer-end food prices leading to consumption changes); whereas other policies target behaviour directly (for example, a social marketing campaign aimed at getting people to eat more vegetables). Similarly, some changes to the food environment, for example, small changes to product composition, may alter diet directly, not mediated through observable behaviour change.

Although the logic pathway is presented as linear, it is recognised that many components of the pathway are inter-related, with feedback loops. For example, changes in food-serving sizes may result in full, partial or no compensation in other aspects of food intake (Rolls, 2009, 2010). Furthermore, changes in physical activity behaviour may result in compensatory changes in eating behaviour (Blundell et al., 2003) and other aspects of physical activity (Lynch et al., 2009; Baggett et al., 2010).

In depicting the impact of changes in dietary intake on disease outcomes, the logic pathway presented in Figure 1 recognises that for some diseases there are good markers of disease risk with good supporting evidence (for example, effect of salt consumption on blood pressure and associated cardiovascular disease risk (He and MacGregor, 2002)); whereas other diseases have fewer markers (for example, changes in fruit and vegetable intake on certain cancers (World Cancer Research Fund/American Institute for Cancer Research, 2007)). The specific intermediate risk factors and health outcomes shown in Figure 1 are intended to be illustrative only, and are based on available evidence of the relationship between risk factors and disease outcomes (Ezzati et al., 2004; World Cancer Research Fund/American Institute for Cancer Research, 2007).

The logic pathway presented in Figure 1 is consistent with those underpinning a number of modelling studies of food policy changes on health outcomes. The interventions modelled in these studies include changes in food advertising (Office of Communications United Kingdom, 2007a), food labelling (Zarkin et al., 1993), food taxes (Nnooham et al., 2009), consumption of snack foods (Lloyd-Williams et al., 2009) and a broad range of obesity-prevention interventions (Haby et al., 2006).

Feasibility of a core nutrient-profiling system underpinning multiple applications

In considering the feasibility of a core nutrient-profiling system to underpin multiple potential applications, it is necessary, first, to consider the different design elements of nutrient-profiling models and the different options available for each element. When designing or selecting a nutrient-profiling
model for a particular application, it is necessary to consider the following questions (Scarborough et al., 2007): are criteria to be across-the-board or food category specific; which nutrients and other food components should be included; which base or combination of bases (for example, per 100 g, per 100 kJ or per serving) is to be used; should the model apply threshold levels or use scoring; and what cutoff numbers should the model adopt. Some of the different options available for each of these questions, their suitability for different purposes and the implications of selecting each option are outlined in Table 2. The discussions in the table are meant to be indicative only, and a broader range of options (and the possibility of combining different options) are likely to be available for each design element. It is recognised that without performing extensive modelling to assess the implications of particular technical decisions on the way in which foods are categorised by a model, it is often not possible to determine the best characteristics of a model to suit the purpose of a particular application.

The different options available in designing and selecting nutrient-profiling models are suited for different purposes and have their relative advantages and disadvantages. For example, it may be appropriate for a model, used to set compositional standards for processed meats, to assess only a very small number of nutrients (for example, fat and sodium content); whereas, a greater number of nutrients are likely to be valuable for models used for food-labelling purposes. As such, it seems unlikely that a single-nutrient profiling model could meet the specific needs of every potential application. Nevertheless, there seems to be scope for some design elements to be common across multiple applications, with additional application-specific criteria applying where necessary. For example, nutrient-profiling models that use scoring systems as their basis are more amenable to adaptation than those that only use thresholds. This is because once a scoring system is in place, different score thresholds can be adopted to suit different purposes. An example of this is the nutrient-profiling model proposed by

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**Figure 1** Logic pathway: changes in food and physical activity policy to changes in health outcomes. The boxes labelled ‘…’ indicate that there are likely to be other components to be taken into account that are not explicitly identified in that step of the pathway. Δ, change in; BMI, body mass index; IHD, ischaemic heart disease; En density, energy density; phys activity, physical activity; Amt, amount; cons, consumed; veg, vegetable; g, grams; ml, millilitres.
### Table 2  Design elements of nutrient-profiling models: the suitability and implications of selecting different options

<table>
<thead>
<tr>
<th>Component of nutrient-profiling model</th>
<th>Options available</th>
<th>Suitability</th>
<th>Implications</th>
<th>Other considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of categories</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| One (‘all foods’) or two (‘foods and beverages’), often referred to as ‘across-the-board’ | When the purpose requires comparing foods across the full range of products, for example, for overall nutrition education and for supporting a shift in consumption from, say, higher fat biscuits to fruit | ● No need to define categories  
● Some foods that are healthier options within their category may be categorised as less healthy overall (for example, olive oil) |  
● Need to define categories  
● Some foods that are unhealthy overall may be categorised as healthy because they are healthier options within their category (for example, meat pies)  
● A greater number of categories is likely to stimulate more product reformulation  
● No consensus on how food categories should be defined  
● Can be difficult to allocate foods to food categories for example, chocolate-coated biscuits could be regarded as confectionery |                      |
| More than two categories, often referred to as ‘food category specific’ | When the purpose requires comparing foods within categories for example, shifting consumption from higher fat to lower fat biscuits |                      |                      |                      |
| **Nutrients and other food components included** |                  |             |              |                      |
| A short list of nutrients and/or other food components | When aiming for a simple, practical model | ● Likely to be more simple to use  
● A short list of nutrients may not reflect all public health concerns  
● Can be useful for targeting specific nutrient deficiencies for example, iron |  
● There are problems in defining some nutrients (for example, if fibre is to be used, the analytical method needs to be specified; and for fruits and vegetables to be used it is necessary to consider what degree of processing is acceptable)  
● Increasing the number of nutrients does not necessarily increase the sensitivity or specificity of models  
● Food composition data may not be available for all nutrients (for example, in Australia it is compulsory to display only eight nutrients on the product label) |                      |
| A long list of nutrients and/or other food components | When aiming for a model which reflects all nutritional concerns | ● Applying a model with a long list of nutrients is likely to be more difficult to use  
● Has the potential to reflect all nutritional concerns |                      |                      |
| **Base used**                         |                  |             |              |                      |
| Per 100 g/100 ml                     | When using a model to categorise foods solely on the basis of the nutrient quality of the food | ● Does not take into account the wide variation in water content of foods and drinks and so different criteria are needed for foods and drinks.  
● Does not take into account the amount of food usually consumed. Foods with very small or very large serving sizes can be categorised in ways which appear anomalous (for example, mustard can appear high in a particular nutrient but is eaten in very small quantities)  
● Is not affected by water content and so does not need different criteria for foods and drinks  
● Does not take into account the amount of food usually consumed. Food with very low or very high energy contents on a per 100 g basis can be categorised in ways which appear anomalous (for example, lettuce may appear high in some nutrients on an energy basis, but a lot of lettuce needs to be eaten to provide those nutrients) |  
● The choice of base is connected with other choices such as the choice of the number of product categories. For example, if a ‘per 100 g/ml’ base is selected there needs to be at least two categories: ‘foods’ and ‘beverages’ |                      |
| Per 100 kJ                           | When using a model to categorise foods solely on the basis of the nutrient quality of the food |                      |                      |                      |
the Food Standards Australia New Zealand (FSANZ) for the regulation of health claims (Food Standards Australia New Zealand, 2008). The preferred model for determining the eligibility of foods to carry health claims was based on the UK Food Standards Agency nutrient-profiling model for use in regulating broadcast advertisements for children (Office of Communications United Kingdom, 2007b). However, the Food Standards Australia New Zealand modified the original UK model (which uses a scoring system) to include an additional score threshold for a new food category (which includes edible oils, edible oil spreads, butter, margarine and cheese).

In addition, it would seem sensible to base a core nutrient-profiling system on a set of nutrients and food components for which data are commonly available. For example, many countries mandate that food labels include nutrition information for a limited number of nutrients, and in many cases, these are the only nutrients for which food composition data are publicly available. In these cases, it may be difficult to include other food components in a nutrient-profiling model used for regulatory purposes. Detailed modelling may be useful here in identifying indicator nutrients that may serve as adequate substitutes for other nutrients (Rayner et al., 2005).

### Table 2  Continued

<table>
<thead>
<tr>
<th>Component of nutrient-profiling model</th>
<th>Options available</th>
<th>Suitability</th>
<th>Implications</th>
<th>Other considerations</th>
</tr>
</thead>
</table>
| Per serving                          | When using a model to categorise foods on the basis of the nutrient quality of the foods and taking some account of how foods deliver their nutrients | ● Need to define serving size  
● Does not take account of all the ways foods deliver their nutrients for example, frequency of consumption | ● Little consensus on how to define serving sizes with no agreed international standards. Where no standards exist, serving sizes are open to manipulation  
● Difficult to define a standard serving size when serving size varies considerably (for example, milk) |
| Method for categorising/ranking products | Thresholds | For simple models designed for a single purpose | ● Less suited to differentiating between products for example, there is no discernable difference between products that narrowly fail to meet a threshold and those that are a long way from the threshold  
● Likely to be most applicable to category-specific models, in which different thresholds can be set for different food categories | |
| Scoring                              | For more complex models that can be tailored for different purposes | ● More flexible in models that can be used for different purposes using different scoring levels depending on the application  
● Model may be harder for users to understand | |
| Cutoff numbers                       | On the basis of dietary recommendations | When there is a need to be consistent with dietary recommendations | ● Maintains consistency across applications for example, the ‘amber’/‘red’ threshold numbers for the UK traffic light scheme are based on Guideline Daily Amounts ((Food Standards Agency United Kingdom, 2007)  
● Algorithms can be developed to combine numbers into a single output for example, an overall score, index or a ratio | |
|                                      | On the basis of existing legislation | When there is a need to be consistent with legislation already in place | ● Maintains consistency across applications for example, the ‘green’/‘amber’ threshold numbers for the UK traffic light scheme boundaries are based on the European Union nutrition claims legislation (Food Standards Agency United Kingdom, 2007) | |
Models that apply to all foods and beverages (‘across-the-board’ models) are well suited to applications, such as marketing regulations, which assess foods across the full range of products. In contrast, applications that aim to compare products within categories, such as compositional standards, are likely to benefit from the increased specificity of models with multiple food categories (‘category-specific’ models). Current evidence suggests that nutrient-profiling models designed to promote a healthy diet should be category-specific but with a limited number of categories (Scarborough et al., 2010). Accordingly, it would seem useful to base a core nutrient-profiling system on a small number of defined food categories that are applied consistently across all applications.

Discussion

This paper has examined the potential applications of nutrient profiling, classifying the potential applications using the ‘Four P’s of Marketing’ framework, and outlining the potential role of these applications in the prevention of DRCD using a logic pathway. The paper has also considered the feasibility of a core nutrient-profiling system to underpin the multiple potential applications. The paper found that there seems to be scope to incorporate a standard scoring method, a common set of nutrients and food components and defined food categories as part of a core nutrient-profiling system, provided that some additional application-specific criteria can be applied.

It is important to be cognisant of the scope and limitations of nutrient profiling. Nutrient profiling cannot be expected to address all DRCD problems. One reason for this is that the nutrient composition of individual foods is not the only determinant of the overall nutrient composition of diets. The portion sizes of individual foods that consumers eat, the frequency of their consumption and the variety of different foods that make up the diets and the combinations in which they are eaten also contribute to the healthiness of the nutrient composition of diets. Furthermore, consumers select foods predominantly on the basis of taste, price, convenience, mood and social norms, with the nutritional value of the food usually being a minor factor (Drewnowski, 2010; Vyth et al., 2010). In addition, ethical concerns (for example, welfare standards for farm animals), religious concerns (for example, methods of slaughtering animals) and environmental concerns (for example, the amount of greenhouse gases emitted during food production) have a role in food-selection decisions. Nutrient-profiling models do not currently take these factors into account. Some of these other factors influencing food choices have been defined (for example, ‘organic’, ‘free range’) so that consumers can have greater confidence in the nature of the foods being purchased, but there is scope for extending this as the recent trial on communicating the greenhouse gas costs of the food production to consumers in Sweden demonstrates (Climate Labelling for Food, 2010).

Although there is potential for using a core nutrient-profiling system across multiple applications, it is recognised that certain conditions would need to be in place to ensure successful development and implementation of such a system. Early and sustained engagement with relevant stakeholders, including governments, the food industry, academia, nutritionists and non-government organisations, are especially critical. Other conditions for success include a clearly defined purpose for the system, a pre-planned and transparent process for developing and reviewing the system, and a realistic approach to model development taking into account understandability, cultural sensitivity and enforceability. Furthermore, this paper has not considered issues relating to implementation, monitoring and evaluation of interventions involving nutrient-profiling models. Important aspects to consider here include, for example, a cost-benefit analysis of whether or not change from existing systems can be justified and, if so, managing the change from existing systems that are well established; gaining government support across jurisdictions and departments; selecting a governance model for enforcement and monitoring; and evaluating the effectiveness of the system. These issues are likely to be country- and region specific and there is an urgent need for national governments and international organisations (such as the World Health Organization) to provide leadership in this area.

Conclusion

There is significant potential for nutrient profiling to be used as a policy tool to improve public health nutrition and reduce the burden of DRCD. As nutrient-profiling models and applications proliferate, there are risks of unnecessary duplication, discrepancies between models, and confusion for regulators, manufacturers and consumers. Accordingly, it is important that countries undertake the necessary analysis and modelling to determine the basic structure of a core nutrient-profiling system to underpin multiple potential applications, and to examine the technical considerations and long-term costs and benefits. This is a relatively new area of research and there remain several technical, policy and implementation issues to be addressed. However, the reality of multiple systems being developed and applied is already upon us. This increases the urgency for international organisations, such as the WHO, to provide guidance to countries on how to proceed in implementing coherent nutrient-profiling systems that can better inform consumer choice and promote population health.

Conflict of interest

The authors declare no conflict of interest.
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