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Horizons in Nutritional Science

Nutrition economics – food as an ally of public health

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Abstract

Non-communicable diseases (NCD) are a major and increasing contributor to morbidity and mortality in developed and developing countries. Much of the chronic disease burden is preventable through modification of lifestyle behaviours, and increased attention is being focused on identifying and implementing effective preventative health strategies. Nutrition has been identified as a major modifiable determinant of NCD. The recent merging of health economics and nutritional sciences to form the nascent discipline of nutrition economics aims to assess the impact of diet on health and disease prevention, and to evaluate options for changing dietary choices, while incorporating an understanding of the immediate impacts and downstream consequences. In short, nutrition economics allows for generation of policy-relevant evidence, and as such the discipline is a crucial partner in achieving better population nutritional status and improvements in public health and wellness. The objective of the present paper is to summarise presentations made at a satellite symposium held during the 11th European Nutrition Conference, 28 October 2011, where the role of nutrition and its potential to reduce the public health burden through alleviating undernutrition and nutrition deficiencies, promoting better-quality diets and incorporating a role for functional foods were discussed.

Key words: Nutrition economics: Health economics: Public health: Cost-effectiveness

Nutrition economics represents an emerging sub-branch of health economics. The term was introduced in early 2010 by a group of multidisciplinary specialists who defined it as 'a discipline dedicated to researching and characterising health and economic outcomes in nutrition for the benefit of society'[1].

Nutrition is undoubtedly a major modifiable determinant of disease. At the recent United Nations general assembly on non-communicable disease (NCD) prevention and control, held in September 2011, the importance of establishing preventative health strategies was widely acknowledged. Such acknowledgement reflects the widening evidence base, which now suggests that if the major risk factors for chronic disease were eliminated, around three-quarters of heart disease, stroke and type 2 diabetes would be prevented along with 40% of cancers. Furthermore, nine million people die prematurely, often before the age of 60 years, from NCD. Over 90% of these premature deaths due to NCD occur in developing countries[2]. Meanwhile, health care expenditure continues to rise faster than economic growth in most high-income countries[3]; in the past 10 years, health care expenditures in countries of the Organisation for Economic Cooperation and Development have increased by 50%. Nutrition economics thus plays a core role in establishing preventative health strategies through food and in the prioritisation of interventional measures, both of which optimise the health and wellbeing of society.

Nutrition economics is relevant in all countries and applies to policies concerning fortified, conventional and functional food entities. The tasks of nutrition economics are first to assess the impact of diet on health and disease prevention,

Abbreviations: QALY, quality-adjusted life years; NCD, non-communicable disease; PAR, population attributable risk.

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expressed in policy-relevant terms, and second to evaluate options for changing dietary choices, including regulatory measures, social marketing, differential pricing, direct service provision and negotiations with industry. Economic evaluation determines the relative efficiency of alternative investment strategies for enhancing wellbeing, and, in the context of nutrition economics, can be employed to ensure that scarce resources are allocated more efficiently to reduce the burden of harm from inadequate-quality diets. A methodological approach for the measurement of health outcomes in nutrition may be considered depending on a three-point continuum of efficacy, effectiveness and efficiency[1]. Efficacy is a standard measure used in randomised controlled trials to determine whether an intervention works under controlled conditions. The outcomes have high internal validity, but often low external validity, and may not be easily generalised. A treatment may be efficacious in randomised controlled trials, but if the treatment is not used in the correct way by people in their everyday life, then the intervention will not have effectiveness. Thus, effectiveness refers to whether an intervention works under real daily life circumstances, without the rigorous compliance conditions applied in efficacy trials. Efficiency adds cost considerations to the latter by asking the question 'is it worth it?'. Value may be defined as the real health outcome per unit of financial investment.

The aim of the present paper is to discuss the role of nutrition and its impact in reducing the public health burden through (i) alleviating undernutrition and micronutrient deficiencies, (ii) promoting healthy choice of conventional foods and (iii) enhancing the use of functional foods for health improvement and disease risk reduction. A further goal is to improve awareness among health professionals, authorities and decision makers and to look at long-term sustainable approaches to enhance health, including the adoption of nutritional strategies. Attaining this goal may require reorganisation of healthcare expenditure models to generate policy-relevant evidence for the implementation of initiatives.

The economic burden of undernutrition

The commitment by governments to eradicate hunger and undernutrition is not only an ethical imperative, but also a sound investment that will yield significant economic gains and major social benefits. Investment in nutrition in early life will benefit not only the present generation, but also their children as well as subsequent generations.

Data on the economic costs of undernutrition help to inform the policy decision-making process. It is important to consider the effects of undernutrition in terms of both its impact on short- and long-term outcomes. Early nutrition defines to a great extent how many people will survive infancy and what quality of life they can expect up until death. Undernutrition and infection in childhood are major determinants of a short life expectancy, while physical activity and diet have greater influence on the causes of morbidity and mortality among ageing populations. Among the leading risk factors for morbidity worldwide, high blood pressure is a major contributor to mortality in both developed and developing countries alike, while tobacco use increasingly influences morbidity in developing countries[4]. Nutrient deficiences, such as Fe, I, Zn and vitamin A, still have an important effect on mortality and disability-adjusted life years among children aged under 5 years in developing countries[5].

While significant gains in life expectancy have been observed in many countries over the last 50 years, a loss in life expectancy has been observed in eight countries of sub-Saharan Africa and in North Korea[6]. A net gain in healthy life years has been demonstrated from the beginning to the end of the twentieth century among American males by an elevation in the age of onset of some chronic conditions, including heart disease, arthritis, neoplasm and respiratory conditions of 7–10 years[7]. Indeed, prevention of morbidity and mortality is demonstrated to have a direct effect on economic growth. In India, half of the recent economic growth may be accounted for by the increasing survival and prevention of disability among the adult population, leading to enhanced productivity in older age. An investment in increasing adult survival rate by 1 % in developing countries is linked to a 0·05 % increase in gross domestic product growth rate, while a similar increase of 1 % in investment:gross domestic product ratio is associated with a 0·014 % increase in growth rate[8].

It is now recognised that early undernutrition has consequences not only in the short term for morbidity, disability and death, but also in the long term for intellectual ability, economic productivity, reproductive performance, diabetes and CVD (Fig. 1)[5]. The link between the timing of investment in human capital and loss of functionality after reaching adulthood has been investigated, showing that the greatest benefit can be achieved from an investment during the initial 1000 days of life (i.e. from the time before conception to the end of the second postnatal year of life) for physical and mental development. What we fail to do in that time period cannot be recovered; for example, iodine deficiency in early life may lead to a loss of 40–50 IQ points in developmental tests, which cannot be improved upon afterwards. Conversely, the present model shows that in fact the greatest investment is made in the last 1000 days of life, and the level of investment here is far greater than that made in the early years of life[9,10].

Stunting is the most common form of undernutrition. At the present time, stunting affects around 178 million children, mainly in Africa and Asia, and to a lesser extent in Latin America[5]. Stunting may be avoided by having an appropriate birth weight and appropriate nutrition over the first years of life; it is almost impossible to reverse stunting after the third year of life. Deviation from the norm in height at the age of 2 years is associated with differences in height at adulthood attained in the analysis of five cohorts from developing countries[11]. Not only is linear growth negatively affected in the early years, but also brain and muscle growth become restricted, which is important in terms of labour productivity and work output, IQ, as well as mental development.

Many countries have targeted school feeding programmes based on low body weight rather than weight for height indices. Foods distributed in such programmes are high-energy/high-protein foods but are often not fortified with adequate micronutrients, resulting in very limited gain in weight and no

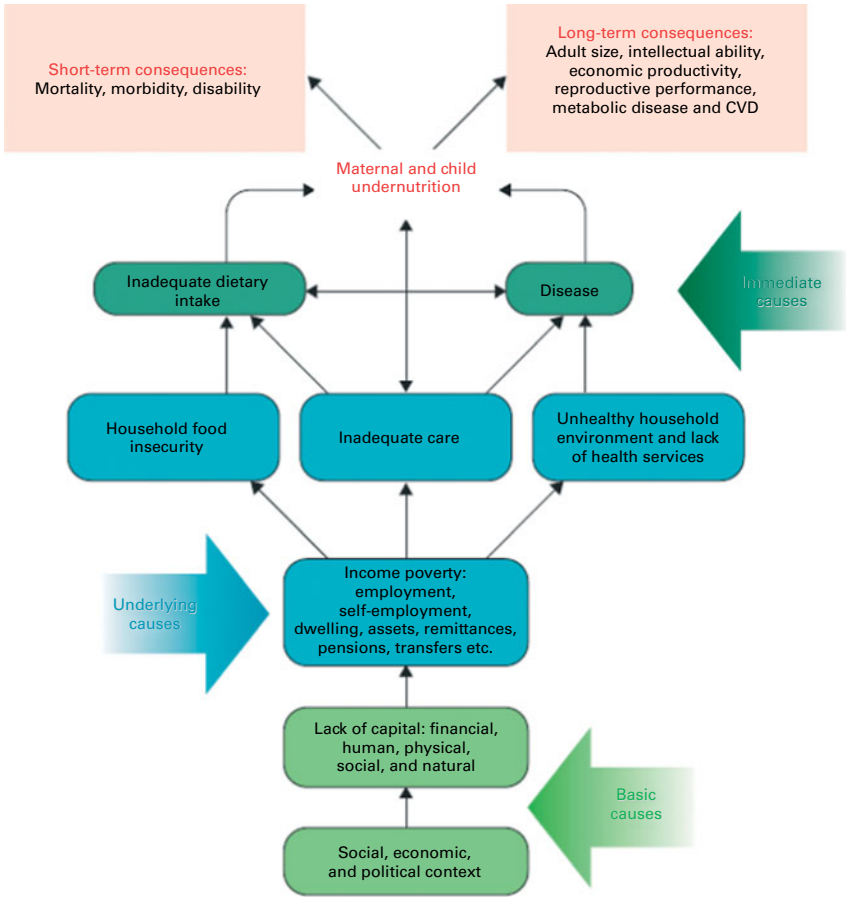

Fig. 1. Maternal and child undernutrition and its short-term and long-term consequences[5].

gain in body length. One of the problems in providing food to undernourished children is that while weight and fat gains may be achieved, less progress is made in terms of length for age, suggesting a trend towards making children heavier and possibly promoting obesity[12]. A better approach would be to target undernutrition during the prenatal period and early years of life.

The consequences of linear growth retardation are multiple. Growth retardation can lead to a higher risk of death in childhood, lower scores in developmental tests (IQ) and in school performance, with higher rates of drop outs and a decrease in lean body mass, which affects physical work capacity. Higher risks of labour complications in women and retarded fetal growth have also been observed. The latter suggests a transgenerational effect of undernutrition in which the effects are passed from the mother to the next generation. The impact of growth retardation is exemplified by a cohort of pregnant Guatemalan women identified in 1975 whose children had been followed up to the age of 35 years[13]. Children who were stunted at 3 years of age ended up being 12 cm shorter than the control group in the same population. Children with severe stunting tended to have 0·6 years less schooling than the control group, so the educational achievement was also less. In adult life, the mean income of this population was 26 000 Quetzales for men and 8000 Quetzales for women, while the severely stunted population had a significantly lower income, at over 3000 Quetzales less among men and 1800 Quetzales less than average among women[13]. This finding suggests that we may be spending money at the wrong time and that a greater investment should be made in early life to maximise productivity, health and wellbeing in adulthood.

The Economic Commission for Latin America and the Caribbean has conducted an evaluation of the economic costs of undernutrition, finding that the economic losses for thirteen countries across the region due to undernutrition amount to US$17 billion or 3·4 % of gross national product on average[14]. Only 8 % of the losses due to undernutrition can be accounted for by poor health and reduction in school attendance at a young age, while lost productivity throughout adult life due to poor educational performance and poor linear growth accounts for as much as 92 % of the loss.

A high proportion of the NCD burden in China can be traced back to nutrition in early life[15]. Stunting was associated with nearly 10 % of cases of CHD, 11 % of strokes and 34 % of type 2 diabetes among the population in 1995. For mortality, in 1995, diet-related NCD were responsible for 2·5 million deaths (or 43 % of all deaths), over 1 million cancer deaths, 1·1 million stroke deaths and 350 000 deaths due to CHD. The economic cost of diet-related NCD in China was estimated at 2·4 % of gross domestic product in 1995.

Prioritising steps to address undernutrition

In the context of limited resources and competing needs, economic impact evaluations contribute to providing valuable information that enables decisions on how to spend effectively and efficaciously, for the greatest benefit relative to money spent. Economic evaluation is a systematic and transparent framework for assessing benefits; it is used to help make decisions and does not make decisions directly. Methodological challenges and uncertainties associated with nutrition interventions to improve health of the next generation, including aspects such as affordability, equity, ethical concerns and political feasibility, need to be addressed. Evaluation of economic impact to prioritise possible steps is both desirable and an inevitable constraint. Economist members of the Copenhagen Consensus panel ranked top priorities for global health measures, taking into account the economic costs and benefits of different measures. In 2004, projects with a good rating for the ability to effect change included two measures to address undernutrition through providing micronutrients and the development of new agricultural technologies, while improving infant and child nutrition and reducing the prevalence of low birth weight were given a fair rating. In the 2008 consensus, steps to address undernutrition were given a higher priority, with five nutritional interventions appearing in the top ten health priorities, including micronutrient supplementation for children (vitamin A and Zn) and micronutrient fortification (Fe and salt iodisation), biofortification of crops, nutrition programmes at school and community-based nutrition promotion.

Economics of nutrition: its role in evidence-policy translation

The three main roles of economics in relation to nutrition are: (i) establishing the cost or burden of disease, that is, defining how big the problem is or how important nutrition is in health and well-being; (ii) economic evaluation, to define which services to expand by comparing the performance across different nutrition interventions and between nutrition and other modalities for improving health; and lastly (iii) establishing how best to achieve the desired change in nutritional behaviour.

Cost of illness/burden of disease

In estimating the burden of poor nutrition, published studies build part of the case for developing and implementing effective interventions. Studies in this area aim to assess the morbidity and mortality attributable to poor diet in terms of years of life lost, disability-adjusted life years lost, deaths and/or quality-adjusted life years (QALY) lost, as well as expenditure on treatment of nutrition-related conditions. The impact on total economic output or indirect costs can also be measured, estimating how nutrition-related diseases affect workforce participation and productivity. Developing these estimates requires good-quality data on the relative risk of disease attributable to alternative foods or whole diet patterns and of present food consumption patterns.

Nonetheless, from the limited published studies, poor diets can be demonstrated to have major implications on the burden of disease. For example, the cost of low dairy consumption on health of Australians has been calculated in a systematic analysis[16]. An initial literature review collated the best published evidence on the relative risk of low *v.* high consumption of dairy products on health, and described the causal pathways between dairy products and disease. A causal link between low dairy product consumption and incidence of disease/risk factors has been established for osteoporosis, obesity, hypertension, IHD, stroke and type 2 diabetes[17–21]. The greatest influence of low dairy product consumption was on the incidence of obesity, based primarily on evidence from the Coronary Artery Risk Development in Young Adults study[20,21].

The population attributable risk (PAR) is the percentage of the disease/condition that is attributable to the particular risk, in this case low dairy product intake. PAR is based on relative risk, consumption patterns and other risk factors that influence disease incidence. In determining total burden, the existence of overlapping causal pathways needs to be adjusted for. For example, obesity is a known risk factor for hypertension, IHD, stroke and type 2 diabetes, and needs to be taken into consideration when assessing the burden of low dairy product consumption to avoid double counting.

The recommended daily dairy product consumption in Australia is two to three servings (the level at which disease risk is minimised), but 65 % of the population fail to regularly meet these recommendations for dairy product consumption[22]. Estimation of PAR for the Australian population suggests that 18 % of cases of obesity could be attributed to low dairy product consumption, and so were 10 % of type 2 diabetes, 16 % of stroke, 8 % of hypertension and 6 % of osteoporosis cases. These values also represent the best estimates of disease that could be avoided by adopting the recommended daily servings of dairy products (Table 1)[16]. For osteoporosis, the percentage of disease found to be attributable to low dairy product consumption seems low; however, there is a serious lack of quality studies of dairy product consumption and incidence of osteoporosis on which to base these calculations.

The PAR may be applied to the burden of disease estimates for each disease type to estimate total burden of disease in terms of health expenditure and morbidity/mortality attributable to low dairy product consumption. PAR applied to published data on the costs of healthcare expenditure associated with each of the six illnesses/risk factors provides estimates for the total health expenditure attributable to low dairy consumption. After adjusting to avoid double counting, health expenditure in Australia attributable to low dairy product consumption for the six disease areas has surged to over AU$2000 million[16]. This amount is approaching the total public health budget in Australia of AU$2265 million. In addition, a substantial total burden in terms of 75 000 disability-adjusted life years was found to be attributable to low dairy product consumption. This research serves to demonstrate the impact that compromised nutrition can have on burden of disease and the potential value of identifying effective and cost-effective approaches to improving diet.

Table 1. Direct healthcare expenditure and burden of disease attributable to low consumption of dairy products in Australia, 2010–11[16]*

	Costs of illness attributable to low consumption of dairy products										
	Base case analysis					Sensitivity analysis S1			Sensitivity analysis S2		
		$million		DALY			$million	DALY		$million	DALY
Disease or risk factor	PAR (%)	Sep†	Σ‡	Sep†	Σ‡	PAR (%)	Σ‡	Σ‡	PAR (%)	Σ‡	Σ‡
Obesity	18·4	1468	1076	54 754	8365	10·1	588	4574	29·8§	1741	13 536
T2DM	10·2	503	237	46 208	18 342	5·1	119	9233	13·0‖	304	23 465
IHD	5·0	122	122	13 638	13 638	2·5	61	6862	14·3¶	347	38 867
Stroke	16·2	238	238	21 873	21 873	8·2	120	11 015	26·4¶	388	35 641
Hypertension	8·3	173	112	17 148	10 794	4·3	58	5608	25·6**	345	33 130
Osteoporosis	6·2	223	223	2000	2000	3·1	112	1006	19·9††	716	6423
Total			2007		75 012		1059	38 299		3839	151 061

DALY, disability-adjusted life year; PAR, population attributable risk; Sep, separately; T2DM, type 2 diabetes mellitus.
* Values are point estimates.
† Application of the PAR to the corresponding estimate of individual direct healthcare expenditure or burden of disease.
‡ Application of the PAR to the corresponding estimate of combined direct healthcare expenditure or burden of disease.
§ Based on combination of data for Australian population and data reported in Pereira *et al.*[20].
‖ Based on data reported in Choi *et al.*[36].
¶ Based on data reported in van der Pols *et al.*[37].
** Based on data reported in Alonso *et al.*[38].
†† Based on data reported in Jaglal *et al.*[39].

Economic evaluation

Economic evaluation is used to evaluate the benefits and costs of a single intervention, or compare the costs and consequences of two or more alternatives in order to best enable resource allocation choices. Economic evaluation typically seeks to express inputs and outputs in monetary terms, in order to calculate a net present value, or return on investment (value of benefits relative to value of costs) of the future stream of benefits and costs, known as a cost–benefit analysis. Health economics more often takes the form of cost–utility analysis, where performance is measured in terms of the cost of achieving a QALY gain, or cost-effectiveness analysis, where performance is expressed as the cost of achieving a predetermined clinical outcome or event. All health economic evaluations need to draw upon the best available clinical evidence.

A cost–utility analysis of a Mediterranean diet after an acute myocardial infarction illustrates the use of economic evaluation. In a controlled trial, 605 patients post-acute myocardial infarction were randomised to either a Mediterranean diet or a low-fat diet recommended by the American Heart Association[23]. A number of clinical events, including death, were gathered up to 5 years post-intervention. Key dietary changes were observed among the Mediterranean diet group, including lower consumption of processed and fresh meat and butter/cream, and a higher consumption of bread, legumes, vegetables, fruits and rapeseed oil margarine. These dietary improvements were associated with between 65 and 72 % reduction in all-cause mortality, major cardiovascular events and stroke over the 5-year follow-up among those receiving the Mediterranean diet compared with those on the American Heart Association diet. Cost per QALY gain for the Mediterranean diet was estimated at AU$1013 (US$703, €579)[24] and the QALY gain per person was estimated at 0·4[25]. These gains compare most favourably with the cost–utility analysis of other nutrition interventions[25]. For example, for the prevention of type 2 diabetes, the cost per QALY gain upon adoption of a reduced fat diet among persons with impaired glucose tolerance was estimated to be AU$10 000, with only a small benefit of 0·024 QALY gain per person, while adoption of an intensive lifestyle among persons with impaired glucose tolerance had greater benefit at a cost–utility of AU$1880, with a QALY gain per person of 0·41[25]. A study of 245 health interventions has reported that lifestyle changes and allied health interventions, which include nutrition intervention, are considerably more cost-effective on average than medical interventions, pharmaceuticals or vaccination (Fig. 2)[26].

Policy translation

Nutrition economics is crucial for the generation of policy-relevant evidence and informed policy decision making to enhance nutrition choices. But does evidence of cost-effectiveness influence policy and practice? From the aforementioned Australian study of 245 health interventions, it was found that cost-effectiveness results do have some influence, notably on what is not funded, tending to exclude services that perform most poorly. However, cost-effectiveness was not found to influence the level of funding, i.e. the likelihood that those in the target group would gain access to funded services. Rather, the major influence on the level of funding and access was found to be funding models. In many countries, including Australia, funding models favour medical and pharmaceutical interventions at the expense of lifestyle and nutrition interventions[27]. This means that specific steps need to be taken to allow the accumulating cost-effectiveness evidence for nutrition interventions to influence policy and practice. Appropriate policy responses should aim to assist citizens to make well-informed nutrition choices. Promoting knowledge of healthy and unhealthy food choices through food labelling and evidence-based social marketing campaigns, taxation of unhealthy foods, subsidising of healthy food choices and restriction of junk food advertising are just a few examples of steps that may be taken to promote healthy nutrition choices.

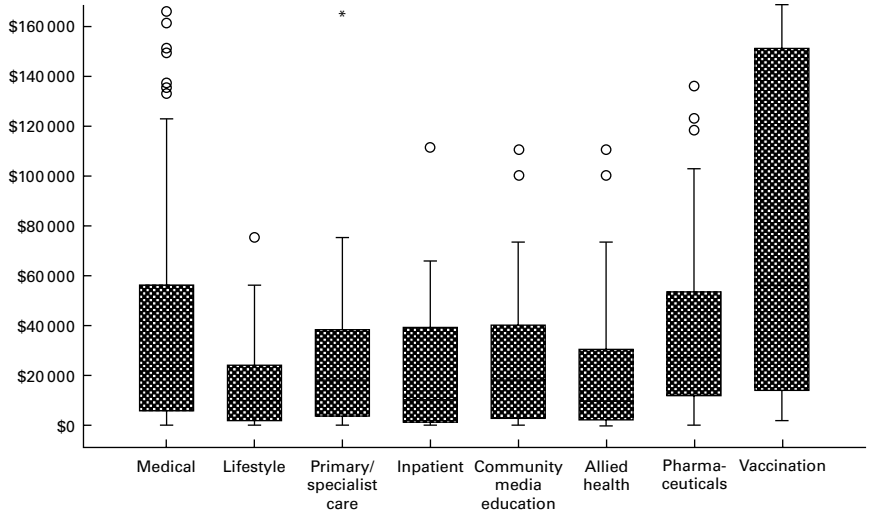

Fig. 2. Box plot: incremental cost-effectiveness ratios for published Australian cost-effectiveness studies of 245 health interventions[26].

Thus, nutrition economics is a crucial partner in the achievement of better nutrition at the population level. It is the discipline for translating evidence on what constitutes a healthy diet into policy, to achieve desired change in patient/consumer/provider/industry behaviours.

Health improvement through (functional) food

The WHO definition of health is 'a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity'. The world is changing, with cancer predicted to be the leading cause of death through to 2030[28]. Society is ageing and more mutations occur as we get older. Diet plays a critical role in the prevention of ill health: cancers can be caused either by inadequacy of nutrients or overindulgence and half of cancers occur in developing countries. Premature death due to NCD is a significant issue that has a huge impact on productivity, and has recently been discussed by the United Nations General Assembly in September 2011. Cancer, diabetes, heart disease and lung disease kill 36 million people worldwide every year, making up 63% of global deaths[29]. Prevention strategies involving dietary and lifestyle changes have been proposed to address this global health problem[29]. However, this is not a new concept, as over 2500 years ago Hippocrates recognised that a balance of healthy diet and physical activity was required to achieve and maintain positive health. The societal and economic benefits of adoption of a healthy lifestyle may be enormous. A WHO report of the Southeast Asia region suggested that at least 80% of cases of premature heart disease, stroke and type 2 diabetes and 40% of cancers could be prevented through lifestyle changes, including a healthy diet, regular physical exercise and avoiding tobacco products. Furthermore, in the Southeast Asia region, a 2% annual reduction in deaths due to chronic disease was shown to be capable of saving over 8 million lives in the next 10 years, of which over 5 million people would be aged <70 years[30]. In India alone, a similar reduction would also result in an economic gain of US$15 billion over the next 10 years. A recent cost analysis from Harvard University suggests that unless present health trends are reversed, the five common NCD – cancer, diabetes, heart disease, lung disease and mental health problems – will cost the world US$47 trillion in treatment costs and lost wages over the next 20 years[31].

Biomarkers for evaluating inter-individual variation in response

Inter-individual variation in the response to food and its components is commonplace. For example, in a study examining the effect of increased olive oil consumption on lowering LDL-cholesterol level, only 25–30% of people responded in the predicted way with a lower LDL-cholesterol level, 10% of people had the opposite response and around 60% of people failed to respond at all[32]. Red meat is associated with an increased cancer risk across a number of studies; a meta-analysis has shown an approximately 20% increased risk of colorectal cancer associated with red meat consumption more than five times per week[33]. A French population study has identified a subpopulation of around 4% with polymorphisms in the cytochrome P450 genes, who have almost a 50-fold increased risk of colorectal cancer from red meat intake when consumed over five times per week[34]. This finding suggests that models for cost-effectiveness may need to consider nutrigenomics and phenotypes, and determination of the cost-effectiveness of many interventions needs to target the population at risk and not the general population.

To adequately determine response to food and components, three types of biomarkers need to be considered, including dietary exposure, susceptibility factors and early biological effect (Fig. 3). What kind of exposure is required and how much need to be determined, as does the kind of desired biological effect. Susceptibility biomarkers may consider how genetic differences influence biological responses.

In the past, general population nutritional campaigns have achieved limited success in terms of positive education regarding food and nutrition. In the future, the food industry

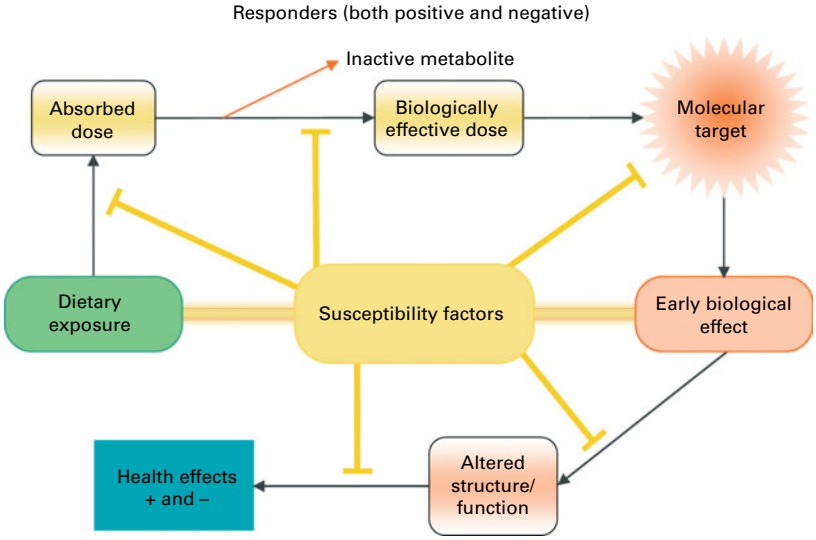

Fig. 3. The three types of biomarkers needed to determine response to foods/components (source: J Milner, unpublished results).

should expand their research focus to individualised health. A paradigm shift from considering the cost of food to modifying foods to give value-added benefits should be considered in terms of health promotion from early life. What is the cost associated with adding nutrients to bring intake up to recommended levels? The economic impact of meeting 2010 federal dietary guidelines for Americans to consume more K, dietary fibre, vitamin D, Ca and to get less energy from saturated fat and added sugar has been examined for the adult population of King County, Washington[35]. Increasing the consumption of K, the most expensive of the four recommended nutrients, was predicted to add US$380 per year to the average consumer's food costs; meanwhile, each time consumers obtained 1% more of their daily energy from saturated fat and added sugar, their food costs significantly declined. Thus, improving diet will require additional guidance for consumers, especially those with little budget flexibility, and new policies to increase the availability and reduce the cost of healthy foods.

In summary, what is the best way to communicate the so-called four Ps for public health promotion: predictive, personalised, pre-emptive and participatory? While biomarkers may be used to accurately predict when adequate levels of nutrients are reached, a personalised approach will account for inter-subject variability in response, pre-emptive timing, e.g. preconception will optimise response and the joint participation of scientists in academia, governments and industry will ensure the best outcome.

Conclusion

The emerging field of nutrition economics aims to assess the impact of diet and health on disease prevention and to characterise the health and economic aspects of specific changes in nutritional behaviour and nutrition recommendations. In the present paper, the importance of translating the influence of nutrition on health and its impact in reducing the public health burden has been illustrated from three different perspectives, i.e. alleviating undernutrition and nutrient deficiencies, enhancing conventional foods and offering selected functional foods. There is a need to improve awareness among health authorities and decision makers of the very considerable benefits of better-quality diets and of the effective and cost-effective policies that can achieve that goal. Nutrition economics has a major role in informing this desirable policy direction.

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