

Obesity 4

Changing the future of obesity: science, policy, and action

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This is the fourth in a [Series](#) of four papers about obesity

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The global obesity epidemic has been escalating for four decades, yet sustained prevention efforts have barely begun. An emerging science that uses quantitative models has provided key insights into the dynamics of this epidemic, and enabled researchers to combine evidence and to calculate the effect of behaviours, interventions, and policies at several levels—from individual to population. Forecasts suggest that high rates of obesity will affect future population health and economics. Energy gap models have quantified the association of changes in energy intake and expenditure with weight change, and have documented the effect of higher intake on obesity prevalence. Empirical evidence that shows interventions are effective is limited but expanding. We identify several cost-effective policies that governments should prioritise for implementation. Systems science provides a framework for organising the complexity of forces driving the obesity epidemic and has important implications for policy makers. Many parties (such as governments, international organisations, the private sector, and civil society) need to contribute complementary actions in a coordinated approach. Priority actions include policies to improve the food and built environments, cross-cutting actions (such as leadership, healthy public policies, and monitoring), and much greater funding for prevention programmes. Increased investment in population obesity monitoring would improve the accuracy of forecasts and evaluations. The integration of actions within existing systems into both health and non-health sectors (trade, agriculture, transport, urban planning, and development) can greatly increase the influence and sustainability of policies. We call for a sustained worldwide effort to monitor, prevent, and control obesity.

Introduction

The prevalence of obesity—defined as a body-mass index of more than 30 kg/m² in adults¹ and according to standards for children specific to age and gender^{2–4}—has been increasing worldwide over the past 30 years in both rich and poor countries, and in all segments of

society.⁵ Clearly, action by governments and other relevant institutions is needed to halt the obesity epidemic, but what measures are justified? Although the associated adverse behaviour is more readily identified than for obesity, the major successes of tobacco control have been linked to the application and implementation of a broad range of policies.^{6,7} Obesity control policy is in many ways more complex.

Obesity is caused by a chronic energy imbalance involving both dietary intake and physical activity patterns. Although the behavioural patterns and their environmental determinants are complex, important causes of the obesity epidemic have been identified.⁸ Evidence shows that increased energy intake is causing the rise in obesity,^{8–13} which is a result of changes in the global food system: the movement from individual to mass preparation “lowered the time price of food consumption”,⁹ and produced more highly processed food (with added sugar, fats, salt, and flavour enhancers), and marketed them with increasingly effective techniques. Additionally, marketing of food and beverages is associated with increasing obesity rates¹⁴ and is especially effective among children,^{15,16} and therefore is a focus of policy strategies.¹⁷ Other factors amplify or attenuate the effect of these causes and produce observed disparities in obesity prevalence across and within populations. National wealth, government policy, cultural norms, the built environment,⁸ genetic¹⁸ and epigenetic mechanisms,¹⁹ biological bases for food preferences,²⁰ and biological mechanisms that regulate motivation for physical activity²¹ all influence growth of the epidemic.

The changes needed to reverse the epidemic are likely to require many sustained interventions at several levels.

Key messages

- Childhood and adult obesity is increasing in countries of high, middle and low income. A growing body of evidence links obesity to short-term and long-term health, social, and economic consequences.
- Empirical evidence of how to prevent obesity is limited but growing. The evidence base needs to be broadened beyond randomised controlled trials to include evaluation of natural experiments, policy changes, and costs.
- Mathematical modelling provides important insights into the causes and dynamics of weight gain and loss. The energy gap framework provides a common metric for translating changes in dietary intake and physical activity into weight change.
- Comparative effectiveness and cost-effectiveness policy and programme analyses indicate that several are both effective and cost saving.
- The application of a systems approach to obesity prevention is novel but already has policy implications including: the need for multiple actions especially in non-health sectors, investments in cross-cutting support systems, policies that target the food and built environments, and additional data for forecasts and evaluation.
- Governments need to lead obesity prevention, but so far few have shown leadership. The food industry has been very active through various pledges, self-regulatory codes, and product reformulation, although the effect of these changes should be independently assessed.
- The UN High-Level Meeting on non-communicable diseases in September, 2011 is an important opportunity for the international community to provide the leadership, global standards, and cross-agency structures needed to create a global food system that offers a healthy and a secure food supply for all.

Necessary alterations include: individual behaviour change; interventions in schools, homes, and workplaces; and sector change within agriculture, food services, education, transportation, and urban planning.²² Despite the overwhelming evidence showing the need to reduce obesity, no clear consensus on effective policy or programmatic strategies has been reached. Most countries do not have sufficient population monitoring data on physical activity, dietary intake, and obesity prevalence to set meaningful goals and assess progress.

The number of suggested interventions, plus the contested nature of potential solutions, can create a “policy cacophony”,²³ which makes the task of obesity prevention appear hopelessly difficult.²⁴ However, applications of quantitative modelling have helped to develop a new science base that provides insights into the dynamics of this epidemic, and brings together different evidence and approaches.^{8,25–27} In this report, we review key findings from these models, including trends in obesity, health, and economic outcomes, the dynamics of weight gain and loss, and the cost-effectiveness of interventions. We outline a strategy for the prevention of obesity that builds on this growing science and specifically links evidence for effectiveness and cost with implementation feasibility and other concerns of policy makers. Finally, we present a call to action from a systems perspective, with a focus on cost-effective and sustainable strategies.

Modelled trends and forecasts

Data from more than 200 countries between 1980 and 2008 suggest steadily increasing obesity prevalence in every region of the world, including in most countries of low and middle incomes, with the steepest rises in higher-income countries.⁵ There are persistent socio-economic and racial or ethnic disparities.^{22,28–31} Despite some evidence for a deceleration of increasing obesity numbers in some high-income countries,³² they still have historically high rates of obesity.

Worldwide rises in obesity prevalence, along with the excess mortality attributed to obesity,³³ have led to forecasts of lowered future life expectancy.^{22,34,35} Furthermore, studies have projected detrimental economic outcomes, such as large increases in short-term and long-term health-care expenditures.^{22,27,36–39}

One hopeful fact is that very few children are born obese. Although there are developmental risk factors for later obesity,^{40,41} infant risks do not explain most adult obesity, and obesity in early childhood commonly disappears later.⁴² Hence policy makers begin each year with a new birth cohort, a low rate of obesity, and the opportunity to maintain this situation in the future. To temper this optimism, quantitative models find that, in the absence of other measures to control obesity, changing rates of early-childhood obesity will, in the short term, have little influence on overall prevalence in the population.^{22,43} Hence, successful strategies to rapidly

lower obesity rates need to target all age groups and take a life-course approach.⁴⁴

Evidence of effective interventions

Commentators worldwide have called for action at many levels to address the growing obesity epidemic,^{8,22,45–47} but what action is justified? Clear evidence supporting cost-effective actions to reduce non-communicable diseases is available.⁴⁸ The evidence base for obesity research has been growing with the development of databases and reviews, generally of randomised controlled trials of preventive and treatment interventions. A 2005 Cochrane review reported some degree of evidence for effective preventive interventions for children.⁴⁹ More recently, the Guide to Community Preventive Services⁵⁰ recorded that behavioural interventions to reduce time in front of computer and television screens prevent obesity in children, and that some counselling interventions (eg, pedometers) and programmes at work are effective in adults. For obese adults, Cochrane reviews suggest small effects of a diet with low glycaemic load,⁵¹ exercise,⁵² or pharmacotherapy,⁵³ but better results for bariatric surgery.⁵⁴ For adults with prediabetes⁵⁵ and obese children,⁵⁶ small effects are observed for dietary and physical activity interventions. There are limited data for interventions in countries of low or middle income.^{57,58}

These reviews, and others,^{59–62} are restricted in both what is studied and the criteria used to assess evidence. By contrast with the path of clinical decision making, in which the evidence base is dominated by randomised controlled trials of high internal validity, the consideration of different types of evidence is valuable—eg, the appraisal of natural experiments and policy changes.^{63–65} The inclusion of broader types of evidence was important in tobacco control: assessments showed that cigarette taxes reduced smoking, a policy change that could not be assessed by randomised controlled trials.⁶⁷ The need for more types of evidence could be particularly important in countries of low and middle income where efficacy studies might not be feasible: flexible methods are needed to investigate large-scale interventions as they are implemented.⁵⁸

Few obesity interventions or policy changes have been subjected to rigorous economic evaluation.^{66,67} Decision makers should also consider implementation issues including feasibility, sustainability, and effects on equity.⁶⁸ Policy makers need to weigh the relative benefits of effective interventions reaching a modest number of people against less effective interventions reaching wider populations. The inclusion of effectiveness, cost, and outcomes—eg, disability-adjusted life-years (DALYs) or quality-adjusted life-years—and implementation issues demands a systems perspective and integrative models.²⁵ The 2011 Strategic Plan for NIH Obesity Research⁶⁹ recognises the importance of comparative and cost-effectiveness research, and highlights emerging methods that enable researchers to model the dynamic complexity

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of obesity and test effects of intervention strategies on individual and societal outcomes.

Dynamics of weight gain and loss and energy gap analyses

As outlined in the third paper in this Series,²⁶ validated mathematical models have clarified the dynamic relations of changes in dietary intake and physical activity to weight change: the energy gap framework provides a common metric—kJ/day (kcal/day)—to describe these changes. Models suggest that the body-weight response to a change of energy balance is slow, with half-times of about a year.²⁶ A small but chronic daily energy imbalance gap has caused the continuing weight gain seen in most countries. Prevention of further average excess weight gain can thus be accomplished with relatively slight changes, in the order of tens of kilocalories per day.²⁶ However, population weight has been accumulating for decades in most countries,⁵ and higher weights need greater energy intakes to maintain. Hence the difference between the energy needed to stop gaining weight and that needed to lose a specified amount of excess weight—the much larger maintenance energy gap—needs to be addressed.²⁶ The Healthy People 2010 goal⁷⁰ in the USA aimed to reduce the proportion of people with excess weight to that found in 1970. With this target, the maintenance energy gap for an average adult in the US currently amounts to about 1 MJ/day (240 kcal/day). For adults with a body-mass index of 35 kg/m² or more (currently 14% of the USA's population⁷¹), more than double this change is necessary.²⁶

As a result, countries should focus on prevention; reversal of obesity trends becomes increasingly difficult as excess weight accumulates. Children are a particularly important focus for action because they have gained little excess weight, and thus small changes are effective.⁷² Large energy-balance changes also take longer to succeed when sequential small changes are involved. Political timetables tend to demand quick results, so support can be difficult to generate if interventions take years to show effect. The energy gap framework can also quantify the effect of different preventive actions: eg, calculations suggest that a typical 9-year-old boy weighing 30 kg expends an extra 630 kJ (150 kcal) by replacing 1.9 h sitting with 1.9 h walking; this action is equivalent to replacing one can of a sugar-sweetened drink with water.⁷²

Cost-effectiveness of obesity interventions

Policy makers are increasingly asking not only whether an intervention works, but also whether it offers value for money. The Australian Assessing Cost-Effectiveness (ACE) in Obesity⁷³ and ACE-Prevention studies⁷⁴ are examples of integrative modelling strategies that assimilate a broad range of evidence to help with resource-allocation decisions. Details of intervention selection, the modelling of intervention implementation, costing of intervention and associated cost-offsets, and the simulation models used are reported elsewhere.^{75,76}

These studies^{73,74} appraised preventive and treatment interventions for obesity: 11 among children and young people and nine among adults. Interventions were modelled with local data and consistent methods to help with cost-effectiveness ranking.⁷³ A stakeholder group assessed the interventions' strength of evidence, effects on equity, acceptability to stakeholders, feasibility of implementation, affordability and sustainability, each of which can affect policy decisions.^{73,74}

The ACE results are presented in the table as cost per DALY averted. The ranking of strength of evidence follows the classification used in ACE⁷⁴ and builds on other research.^{68,81–84} Studies assumed a decision threshold of A\$50 000 (US\$49 500) per DALY prevented to establish whether an intervention was cost effective or not, which is in line with empirical evidence on what constitutes acceptable value-for-money in Australia.^{85,86} Use of standard methods improves the comparability of results, although lower strength of evidence for many interventions limits the generalisability of findings, and costs can vary.

Eight of the 20 interventions were found to be both health-improving and cost saving (so-called dominant interventions; the first eight listed in the table). The next three were very cost-effective in that they improved health at a cost of less than A\$10 000 per DALY prevented; and the next three listed improved health at a cost of between A\$10 000–50 000 per DALY prevented. The first 11 interventions in the table (eight dominant and three highly cost effective) should only be ignored and not implemented if decision makers have serious reservations about the evidence base, or are faced with insurmountable difficulties in relation to other considerations such as their implementation feasibility, equity impacts, or acceptability to stakeholders.

The top three money-saving interventions (the first three listed in the table) are environmental. They show modest effects at an individual level but prove highly cost-effective, because benefits accrue to the entire population and the cost of implementation is relatively low.⁸¹ However, these interventions vary in terms of the sufficiency of evidence related to their effectiveness and differences in the likelihood of their implementation.

Although reduction of television advertising of unhealthy food and beverages to children was found to be one of the most cost-effective interventions, regulation of advertising has not been on the political agenda of the Australian Government, so implementation is highly unlikely.⁸⁷ The evidence on front-of-pack traffic light nutrition labelling was considered insufficient to warrant support of policy makers in Australia, despite plausible outcomes.⁷⁷

An over-riding conclusion of the ACE assessments is that policy approaches generally show greater cost-effectiveness than health promotion or clinical interventions (table). This conclusion is borne out by other studies: eg, regulatory and fiscal interventions (such as regulation of food advertising to children) were

| | Target population | Strength of evidence* | DALYs saved | Gross costs† (A\$ million) | Net cost per DALY saved‡ (A\$ million) |
|---|--|-----------------------|-------------|----------------------------|--|
| Unhealthy food and beverage tax (10%)§ ⁷⁷ | Adults | 4 | 559 000 | 18.00 | Cost-saving |
| Front-of-pack traffic light nutrition labelling§ ⁷⁷ | Adults | 5 | 45 100 | 81.00 | Cost-saving |
| Reduction of advertising of junk food and beverages to children¶ | Children (0–14 years) | 2 | 37 000 | 0.13 | Cost-saving |
| School-based education programme to reduce television viewing¶ | Primary schoolchildren (8–10 years) | 3 | 8 600 | 27.70 | Cost-saving |
| Multi-faceted school-based programme including nutrition and physical activity¶ | Primary schoolchildren (6 years) | 3 | 8 000 | 40.00 | Cost-saving |
| School-based education programme to reduce sugar-sweetened drink consumption¶ | Primary schoolchildren (7–11 years) | 3 | 5 300 | 3.30 | Cost-saving |
| Family-based targeted programme for obese children¶ | Obese children (10–11 years) | 1 | 2 700 | 11.00 | Cost-saving |
| Multi-faceted targeted school-based programme¶ | Overweight/obese primary schoolchildren (7–10 years) | 3 | 270 | 0.56 | Cost-saving |
| Gastric banding—adolescents¶ ⁷⁸ | Severely obese adolescents (14–19 years) | 1 | 12 300 | 130.00 | 4 400 |
| Family-based GP-mediated programme¶ ⁷⁹ | Overweight/moderately obese children (5–9 years) | 3 | 510 | 6.30 | 4 700 |
| Gastric banding—adults§ | Adults BMI >35 kg/m ² | 1 | 140 000 | 120.00 | 5 800 |
| Multi-faceted school-based programme without an active physical activity component¶ | Primary schoolchildren (6 years) | 3 | 1 600 | 51.20 | 21 300 |
| Diet and exercise§ | Adults BMI >25 kg/m ² | 1 | 3 000 | 140.00 | 28 000 |
| Low-fat diet§ | Adults BMI >25 kg/m ² | 1 | 1 900 | 94.00 | 37 000 |
| Active After Schools Communities Program¶ ⁸⁰ | Primary schoolchildren (5–11 years) | 5 | 450 | 40.3 | 82 000 |
| Weight Watchers§ | Adults | 1 | 54 | 5.00 | 84 000 |
| Lighten up to a healthy lifestyle weight-loss programme§ | Adults | 4 | 38 | 4.00 | 94 000 |
| TravelSMART schools¶ | Primary schoolchildren (10–11 years) | 4 | 90 | 13.10 | 117 000 |
| Orlistat§ | Adults BMI >30 kg/m ² | 1 | 2 100 | 1 500.00 | 700 000 |
| Walking School Bus¶ | Primary schoolchildren (5–7 years) | 3 | 450 | 40.30 | 760 000 |

BMI=body mass index. *This classification (1=strongest; 5=weakest) is based on criteria adopted in ACE-Prevention.⁷⁴ 1=sufficient evidence of effectiveness. Effectiveness is shown by sufficient evidence from well-designed research that the effect is unlikely to be due to chance (eg, p<0.05) and is unlikely to be a result of bias (eg, evidence from: a level I study design; several good quality level II studies; or several high quality level III-1 or III-2 studies from which effects of bias and confounding can be reasonably excluded on the basis of the design and analysis). 2=likely to be effective. Effectiveness results are based on sound theoretical rationale and programme logic, and level IV studies, indirect or parallel evidence for outcomes, or epidemiological modelling to the desired outcome using a mix of evidence types or levels. The effect is unlikely to be due to chance. Implementation of this intervention should be accompanied by an appropriate evaluation budget. 3=limited evidence of effectiveness is demonstrated by limited evidence from studies of varying quality (can be level II or III studies). 4=may be effective. Effectiveness is similar to evidence of strength 2 but potentially not significant and bias cannot be excluded as a possible explanation. 5=inconclusive or inadequate evidence (5 or 6 in original studies). †Gross costs=intervention costs. ‡Net cost per DALY saved=Gross costs minus cost offsets divided by number of DALYs saved (costs only for reductions in obesity-related disease and not including unrelated health-care costs). §Interventions drawn from ACE-Prevention study 2010.⁷⁴ ¶Interventions drawn from ACE-Obesity study.⁷³

Table: Cost-effectiveness results for selected interventions evaluated in Australia

the least expensive measures among those examined by the Organisation for Economic Co-operation and Development (OECD).^{88,89} The OECD argued that fiscal measures were the only interventions likely to pay for themselves—ie, they were likely to generate larger savings in health expenditure than costs of delivery.⁸⁸

Translation of cost-effectiveness results to other settings

The translation of ACE findings into practice in other countries might require modifications. A tax of 10% on so-called unhealthy food and beverages has not been a strong focus in the USA, but an excise tax on sugar-sweetened beverages has received much discussion.⁹⁰ The evidence base for an intervention on sugar-sweetened beverages reducing excess caloric intake and weight is reasonably strong,⁹¹ intake is high,^{92,93} and a tax can raise billions of US dollars per year for cash-starved states.⁹⁰ Contrasting tax structures mean individual countries are more or less amenable to such changes.

Regulations to limit marketing of unhealthy foods and beverages to children vary widely across countries, with some more and others less restrictive than Australia. The USA has a lot of television advertising (18 min/h), but freedom of speech issues limit regulatory options. Nevertheless, corporate tax deductibility of advertising costs for unhealthy foods could be restricted.⁹⁴

Some community-based programme interventions were found to be cost effective in both ACE and OECD studies,^{73,74,88} but effects often depend on sustained public funding. Many programmes are confined to specific target populations, which limits beneficiaries; some clinical interventions offer large benefits to individuals, but apply to relatively small populations.

Similar modelling exercises have been used by others. As policy makers wrestle with limited budgets, the ability to identify cost-effectiveness is in great demand. OECD models of multiple interventions have informed government planning in high-income countries^{88,89} and in those of low and middle income.⁹⁵ In the UK, Foresight

Panel 1: Implications of a systems approach (adapted from Institute of Medicine⁶⁴)

- A comprehensive approach will be needed to address the main causes of the epidemic and minimise the risk of compensatory actions. For example, a ban on food advertising during designated children's television programmes should not result in increased advertising in other programmes that children watch.
- Integrated interventions throughout society—individuals, families, local, national, and international—that recognise that individual choices are shaped by the wider context.
- Core investments in coordination, networking, and communications to maximise effect.
- Interventions across the life course for all demographic groups to reinforce and sustain long-term behavioural change.
- Use of diverse interventions that combine direct initiatives (which influence energy balance), structural actions (which inform and enable change and indirectly affect energy balance), and amplifiers (which address social norms and other contexts).
- Long-term plans will allow early initiatives to set the scene for subsequent interventions. Early interventions may be visible but limited, but they are the platform to achieve more comprehensive, systems-oriented actions.
- Governments should fund continuing research and evidence gathering, including monitoring at the population level and evaluation of interventions, to measure the problem and identify solutions.
- Obesity should be considered alongside other major issues that confront societies (development in countries of low and middle income, reduction of poverty in all countries, a sustainable food supply, and action against climate change), because they all have strong links with obesity prevention, including common causes and solutions.

undertook analyses²² useful to the cross-government strategy *Healthy Weight Healthy Lives*. Additionally, the UK National Institute for Health and Clinical Excellence has published cost-effectiveness studies of health-care interventions,^{96,97} as has the Dutch Centre for Public Health and the Environment.⁹⁸

A systems approach to obesity prevention

Even the most effective interventions will not be sufficient to reverse the obesity epidemic individually. Solutions need to be multifaceted, with initiatives throughout governments and across several sectors. Interventions that might have quite small effects when assessed in isolation may still constitute important components of an overall strategy. An additional challenge for countries of low and middle income is the continuing dual burden of both undernutrition and obesity.⁵⁸

A recent Institute of Medicine panel on evidence and obesity decision making outlined the need for consideration of a broad range of evidence and for a systems perspective.⁶⁴ New thinking and approaches, and the use of computational modelling are needed to create a better understanding of the interconnectedness and synergies of the whole system, and of its individual components or sub-systems. The Institute of Medicine report⁶⁴ borrowed from the Foresight strategic framework²² to articulate major implications for policy making (panel 1).

Call to action

UN Member States will gather in New York, USA, in September, 2011 for the first High-Level Meeting of the

UN General Assembly focused on non-communicable diseases. The global obesity epidemic, described as a “wicked problem” because of its complex and intractable nature,⁹⁹ will be a challenge for Member States because none of them have adequately dealt with the obesity epidemic. The meeting is in response to the overwhelming need for action: non-communicable diseases are a barrier to development in countries of low and middle income. Obesity prevention is a major part of this effort. What actions are needed and what can be implemented?

WHO's Global Strategy on Diet, Physical Activity and Health⁴⁷ provides a framework for action on both child and adult obesity prevention that is linked to other WHO strategies, (eg, prevention of non-communicable diseases).¹⁰⁰ The Global Strategy framework encompasses many levels of jurisdiction across a wide range of health service policies, health promotion programmes, environments related to food, physical activity, and the socioeconomic determinants of health.^{101,102} Several authoritative reports have developed priority actions needed at global and national levels.^{47,103–108} The recommendations are consistent, although many are broad to accommodate different settings. Recommendations for obesity prevention tend to divide into two broad categories of actions. Direct actions use logical pathways from intervention to energy balance, and their cost-effectiveness has been documented.^{73,74,88,89,95–98} However, a systems approach reminds us of the importance of structural or cross-cutting interventions that support direct actions, but for which cost-effectiveness evidence is not available (eg, what is the cost-effectiveness of an obesity monitoring system?). This message is especially important for countries of low and middle income that need to boost structures supporting workforce skills, and knowledge creation and exchange for public health. Most countries still need basic data: only a third of European Union nations have representative data on children's weight and height.¹⁰⁹ Even fewer countries have set targets for rates of obesity or for changes in determinants such as dietary intake and physical activity. Political leadership for action is low in many countries; the interest of the US First Lady, Michelle Obama, in the issue of obesity shows the value of such attention.¹¹⁰

The main actors**Governments**

Governments are the most important actors in reversing the obesity epidemic, because protection and promotion of public goods, including public health, is a core responsibility. They operate at local, state, and national levels as well as being major stakeholders as Member States in most international agencies such as the UN. The repercussions of obesity mainly burden the health system, but ministries outside health, such as finance, education, agriculture, transportation and urban planning, arguably have the greatest influence in creating environments conducive to prevention.

Panel 2: Core actions for governments

Leadership and governance

- Show high-level leadership by supporting actions to reduce obesity
- Introduce cross-sectoral structures to ensure support
- Establish mechanisms that limit the influence of commercial interests in policy making

Healthy public policies

- Protect and promote health and sustainable food security as over-riding priorities in food policy development
- Ensure trade agreements and agricultural and food fiscal policies (eg, subsidies, taxes, import tariffs, and quotas) protect and promote health
- Prioritise public transport, walking and cycling environments, and safe recreation spaces in transport and urban planning policies and budget allocations
- Ensure taxation and social policies support the reduction of socioeconomic inequalities that contribute to health inequalities

Resources

- Commit funding for preventive health including targeted effective direct and structural actions
- Include health promotion activities within other existing budgets (eg, treatment services, education, and local government)
- Establish health promotion foundations and fund through taxes on tobacco, alcohol, or unhealthy food and beverages

Intelligence systems

- Create monitoring systems to track obesity trends in children and adults and key aspects of the food and physical activity environments (eg, nutrient composition of foods, and exposure of children to marketing)
- Identify and support centres with expertise in obesity prevention research and assessment within academic institutions
- Establish knowledge-exchange mechanisms to share evidence and experiences

Support systems for policy implementation

- Adopt nutrient profiling systems to underpin food and nutrition policies (eg, front-of-pack traffic light labelling, and regulations on marketing to children)
- Support healthy food-service policies implemented by public and private sector organisations and support physical activity
- Set standards and guidelines for local authorities to create environments for active transport and recreation

Workforce capacity and development

- Employ sufficient, skilled staff within the prevention workforce
- Include nutrition, physical activity and the prevention of obesity within curricula for health and related professionals (eg, planners, teachers, child care workers)
- Expand quality postgraduate courses, including PhD opportunities, within countries of low and middle income

Partnerships, organisational relationships, and networks for coordination

- Instigate cross-sectoral structures at the national and state level to coordinate activities across governments, non-governmental organisations, private sectors, and at the local level

Communications

- Communicate and update national guidelines for individuals on healthy eating and physical activity
- Establish and communicate national targets for the food industry on food composition, marketing to children, and food claims
- Provide consistent messages through effective social marketing communications that motivate individuals to adopt healthy lifestyles and create healthy environments for others, especially children

Although many governments have developed guidelines and strategic plans to improve dietary and physical-activity patterns, the translation into action has been disappointing. Almost all food policies recommended as priority actions, including front-of-pack traffic light labelling, have been heavily contested by the food industry, so implementation is politically difficult. However, several of these direct actions are now well supported by cost-effectiveness evidence.^{73,74} Less contested areas of action, such as school and community actions, social marketing, and promoting physical activity, find greater political favour even though the costs may be substantial and the benefits uncertain. The single major investment in obesity prevention by the Australian Government led by John Howard until

2008 was A\$214 million for an active after-school programme,¹¹¹ which was not even recommended by their own National Obesity Taskforce.¹¹² Authoritative groups, including WHO,^{47,100-105} have recommended actions for governments (core, structural recommendations shown in panel 2).

International agencies

The UN and other international bodies need to take action to reduce obesity (panel 3). Many international agencies affect food and public health. The UN has several core agencies directly involved in health and development including WHO, the Food and Agriculture Organisation, UNICEF, the UN Development Programme, and the World Food Programme, in addition

Panel 3: Key actions for international agencies, the private sector, civil society, health professionals, and individuals

International agencies

- The UN, its Member States, and agencies should provide global leadership through commitments for increased funding and policy support for prevention of obesity and non-communicable diseases.
- The protection and maintenance of public health should be considered in relevant trade, economic, agriculture, environment, food, and health agreements and policies.
- The UN should implement and coordinate policies and funding to prevent obesity and non-communicable diseases across its agencies.
- WHO should develop global standards, particularly for food and beverage marketing to children and for nutrient profiling.

Private sector

- Processed food and beverage industries should reformulate existing products and develop new ones with healthier nutrient compositions, particularly through feasible reductions in sugar, salt, and unhealthy fat.
- Food and beverage, and communications industries should apply voluntary restrictions on all forms of marketing promotions of foods high in sugar, salt and unhealthy fat to children and adolescents.
- Food and beverage industries, and food retailers should ensure food labelling, packaging, and health claims meet high standards in all countries.
- The private sector needs to use all available strategies to support public health efforts to create healthier food systems.
- Relevant industries need to support efforts to monitor progress towards healthier food systems by the sharing of relevant data, which helps governments to assess progress towards targets while protecting commercially sensitive information.

Civil society

- Alliances and networks could be formed to share information, build the constituency for change, and advocate for the policies and programmes to reduce obesity.
- Policies and practices of the other parties should be monitored. Civil society should hold these parties to account for their actions, inactions, or counteractions in relation to promotion of healthier environments and reduction of obesity and chronic disease.

Health professionals

- Health professionals need to monitor the weight of patients and offer suitable evidence-informed advice about maintaining a healthy bodyweight.
- Physicians should provide continuing support (or refer for support) those patients ready to undertake a weight-loss programme.

Individuals

- Parents and caretakers should act as role models for health-promoting behaviours for children and adolescents.
- Individuals need to make healthy food and activity choices, and help to create healthy food and physical activity environments in homes and other settings, such as schools, workplaces, sports clubs, churches, and community organisations.

to interagency bodies such as the Standing Committee on Nutrition and the Codex Alimentarius Commission. Although 60% of global mortality results from non-communicable diseases and 80% of premature deaths caused by these diseases are in countries of low or middle income,¹¹³ only 12% of WHO's budget is allocated to non-communicable diseases.¹¹⁴ More support is needed for the UN Standing Committee on Nutrition,

the coordinating body for food and nutrition activities across UN agencies: in 2010, this body almost closed because of lack of funding.¹¹⁵

Also powerful are the political, economic and trade-related multi-national bodies including the World Trade Organisation, the World Bank, International Monetary Fund, European Union, and the informal groups G8, G20, and G70. Although public health is not the primary concern of these groups, their actions can have profound effects on it, including obesity and chronic disease, and public health can affect the economy of nations.

Private sector

The private sector includes industries involved in foods and beverages and their representative organisations, the media, and industries responsible for the built environment. This sector shapes the food and activity environments we live in and, through communications and marketing, also alters people's perceptions, desires, and accepted norms. Active support from all these industries is needed to reduce obesogenic environments (panel 3); they have the collective power to achieve this change, even though they have been criticised for their part in creating these surroundings. The food and beverage industries in particular have taken steps in recent years to respond to the obesity epidemic as individual companies and through representative organisations.¹¹⁶ Whether various actions and pledges by these industries can reduce obesity is uncertain, so rigorous independent evaluation is needed. The most powerful activities by the private sector relevant to public policy are undoubtedly lobbying activities, which often undermine policies aimed at reducing obesity—eg, in relation to regulations on marketing to children, traffic light labelling, and taxes on unhealthy foods.

Civil society

Civil society organisations include public interest and consumer associations, charities, academic institutions, foundations, professional associations, and other community, religious, and advocacy groups. They have limited funding and hold less power than other actors, but they fill important advocacy and watchdog roles. These organisations tend to be at the forefront of lobbying for healthy, sustainable, and fair environments, and should continue to do so (panel 3), although in some non-democratic countries their freedom to speak out for change is significantly curtailed. Generally, advocacy activity in countries of low and middle income is limited and global non-governmental organisations can have an important supporting role.

Health professionals

Support provided by physicians can help to improve diet and physical activity, which can assist individuals to maintain or lose weight (panel 3).^{96,97}

Individuals

The final choices for eating behaviours and physical activity rest with individuals (panel 3), although in many environments the available options might already be limited. Parents and caregivers have particular responsibilities and greatest opportunities to promote lifelong healthy behaviours among children and adolescents.

Conclusion

This Series in *The Lancet* documents the emerging science of obesity prevention and control. The obesity epidemics in countries throughout the world are driven by complex forces that require systems thinking to conceptualise the causes and to organise evidence needed for action. Applications of quantitative modelling have made possible both planning for and evaluation of the effect of actions to prevent and control obesity. These models include energy gap models of individual and population weight gain and loss, forecasts of long-term economic and health outcomes, and cost-effectiveness analyses of programmes and policies. A rapid increase of efforts is needed. The UN High-Level Meeting on non-communicable diseases in September, 2011 provides a key opportunity to strengthen international leadership from the UN and its agencies, and to stimulate other agencies and states to begin to seriously address the continuing global epidemic of obesity. Beyond that meeting, the test will be how well Member States match their declarations with supportive funding and policies to support global actions.

Contributors

All authors jointly formulated the major concepts, and read and approved the final version of the paper. SLG provided overall leadership on development and drafted the paper. MLM and RC drafted the section on ACE cost-effectiveness and reviewed paper drafts. BAS and MLM drafted the systems thinking and call to action section and reviewed drafts. DL, DLF, PLM, TH and TM provided comments on successive drafts of the paper.

Conflicts of interest

We declare that we have no conflicts of interest.

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