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Changing the Future of Obesity: Science, Policy and Action

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Abstract

The global obesity epidemic has been on the rise for four decades, yet sustained prevention efforts have barely begun. An emerging science using quantitative models has provided key insights into the dynamics of this epidemic, and made it possible to combine different pieces of evidence and calculate the impact of behaviors, interventions and policies at multiple levels – from person to population. Forecasts indicate large effects of high levels of obesity on future population health and economic outcomes. Energy gap models have quantified the relationships of changes in energy intake and expenditure to weight change, and documented the dominant role of increasing intake on obesity prevalence. The empirical evidence base for effective interventions is limited but

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Author contributions

All authors jointly formulated the major concepts, and read and approved the final version of the manuscript. SG provided overall leadership on development and drafted the paper. MM and RC drafted the section on ACE cost effectiveness and reviewed paper drafts. BS and MM drafted the systems thinking and call to action section and reviewed drafts. DL, DF, PM, TH and TM provided comments on successive drafts of the manuscript.

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growing. Several cost-effective policies are identified that governments should prioritize for implementation.

Systems science provides a framework for organizing the complexity of forces driving the obesity epidemic and has important implications for policy-makers. Multiple players (including governments, international organizations, 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, health-in-all policies, and monitoring), and much greater funding for prevention programs. Increased investment in population obesity monitoring would improve the accuracy of forecasts and evaluations. Embedding actions within existing systems in both health and non-health sectors (trade, agriculture, transport, urban planning, development) can greatly increase impact and sustainability. We call for a sustained worldwide effort to monitor, prevent and control obesity.

Introduction

The obesity[1–4] epidemic has grown worldwide, in countries both rich and poor, and among all segments of society. Action by government and other relevant institutions is clearly needed to halt the obesity problem, but what action is justified? In tobacco control, the adverse behavior is more readily identified, but even in this case major successes of the past have been linked to the application and implementation of a broad range of policies.[5,6] 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. While these behavioral patterns and their environmental determinants are complex, important drivers of the obesity epidemic have been identified.[7] Evidence indicates that increases in energy intake are driving recent obesity increases.[7–12] Key drivers include changes in the global food system that moved from individual to mass preparation, "lowered the time price of food consumption,"[8] produced more highly processed food (adding sugar, fats, salt and flavour enhancers), and marketed them with increasingly effective techniques. Marketing foods and beverages is especially effective among children,[13,14] is associated with obesity prevalence,[15] and has been a focus of policy strategies.[16]

Other moderators amplify or attenuate the impact of these drivers and produce observed disparities in obesity prevalence across and within populations: these include national wealth, government policy, cultural norms, the built environment,[7] genetic[17] and epigenetic mechanisms,[18] biological bases for food preferences[19] and biological mechanisms that regulate motivation for locomotion and contribute to the decline in physical activity from childhood into adulthood.[20]

The changes needed to reverse the epidemic will likely require many interventions that span multiple levels and are sustained for many years. These include individual behavior change, setting change in schools, homes and workplaces, and sector change within agriculture, food services, education, transportation and urban planning.[21] While there is overwhelming evidence on the need to reduce obesity, there is less clear consensus on effective policy or programmatic strategies. Most countries lack sufficient population monitoring data on physical activity, dietary intake and obesity prevalence for meaningful goal setting and assessment of progress.

These characteristics plus the contested nature of potential solutions can create a "policy cacophony,"[22] making the task of obesity prevention appear hopelessly difficult.[23] However, recent applications of quantitative modeling have helped develop an emerging

new science base that provides key insights into the dynamics of this epidemic, and brings together different pieces of evidence and approaches.[7,24–26] In this paper we review key insights from these quantitative models, including trends in obesity, health and economic outcomes, the dynamics of weight gain and loss, and cost-effectiveness of different interventions. We outline a strategy for the population prevention of obesity that builds on this growing science, and specifically links evidence for effectiveness and cost with implementation feasibility and other policymaker concerns. We outline a call to action utilizing a systems perspective with a focus on cost-effective and sustainable strategies.

Modeled Trends and Forecasts

Modelled trends from more than 200 countries (1980–2008) indicate steadily increasing obesity prevalence in every region of the world, including most low and middle income countries, with steepest increases in higher income countries.[27] There are persistent socioeconomic and racial/ethnic disparities.[21,28–31] Despite some evidence for a flattening of upward obesity trends in some high income nations,[32] these countries are still at historically high levels.

Worldwide increases in obesity prevalence along with the excess mortality attributed to obesity [33] have led to forecasts of lowered future life expectancy.[21,34,35] Studies have projected large increases in short and long term health care expenditures and other economic outcomes as a consequence of obesity. [21,26,36–39]

One hopeful characteristic is that children are rarely born obese. Although there are developmental risks factors for later obesity,[40,41] infant risks explain little of adult obesity, and early childhood obesity often changes.[42] Hence policymakers begin each year with a new birth cohort and a low rate of obesity, and the opportunity to maintain this level in the future. Tempering this optimism, however, quantitative models find that, in the absence of other measures to control obesity, changing rates of early childhood obesity will, in the short run, have a relatively small influence on overall population prevalence.[21,43] Hence, successful strategies to rapidly lower population obesity need to change risks among all age groups, employing a life course approach.[44]

Evidence of Effective Interventions Based on Empirical Data

Commentators worldwide have called for action at many levels to address the growing obesity epidemic[7,21,45–47] But what action is justified? Recent studies have cited clear cost effective evidence for action to reduce noncommunicable disease (NCD)'s.[48] The evidence base for obesity research has been growing, with the development of databases and reviews of studies, generally randomized controlled trials (RCTs) of preventive and treatment interventions. A 2005 Cochrane review indicated limited evidence for effective preventive interventions for children.[49] More recently the Guide to Community Preventive Services reported that behavioral interventions to reduce screen time are effective in preventing obesity in children, and that some counseling interventions (e.g. with pedometers) and worksite programs are effective in preventing obesity in adults.[50] For obese adults, Cochrane reviews indicate small effects for a low glycaemic load diet,[51] exercise,[52] or pharmacotherapy,[53] and larger effects for bariatric surgery.[54] For adults with prediabetes[55] and obese children, small effects are observed for dietary and physical activity interventions.[56] There is limited evidence for interventions in low and middle income countries.[57,58]

These and others reviews of interventions[59–62] are limited in both what is studied as well as the criteria used to evaluate evidence. Rather than following the path of clinical decision-making where the evidence base is dominated by RCTs with high internal validity, there is

value in considering different types of evidence, for example evaluating natural experiments and policy changes.[63–65] The consideration of broader types of evidence was important in tobacco control. Evaluations indicated the clear effectiveness of cigarette taxes in reducing smoking, a policy change where RCT's are not possible.[5,6] The need for broader forms of evidence may be particularly important in low and middle income countries where efficacy studies may not be feasible: flexible methodologies are needed so large-scale interventions can be evaluated as they are implemented.[58]

Policymakers are increasingly asking not only whether an intervention works, but whether it offers value-for-money. Few obesity interventions or policy changes have been subjected to rigorous economic evaluation.[66,67] Implementation issues are also critical for decision makers, including feasibility, sustainability and effects on equity.[68] Policy-makers may need to weigh the relative benefits of effective interventions reaching a modest number of people with less effective interventions reaching wider populations. Including effectiveness, cost, and outcomes (e.g. Disability Adjusted Life Years (DALY)) as well as implementation issues demands a systems perspective and integrative models.[6] The recent Strategic Plan for NIH Obesity Research recognizes the importance of comparative and cost effectiveness research, and highlights emerging methodologies that enable researchers to model the dynamic complexity of obesity and test effects of intervention strategies on individual and societal outcomes.[69]

Modelled Evidence: Dynamics of Weight Gain and Loss and Energy Gap Analyses

As outlined in the second paper in this series, validated mathematical models have clarified the dynamic relationships of changes in dietary intake and physical activity to weight change. The energy gap framework provides a common metric (kj/day (kcal/day)) to use in describing these changes, and models indicate that the body weight response to a change of dietary energy intake is slow, with half-times of about one year.[25] A small but chronic "Daily Energy Imbalance" gap has driven the continuing weight gain seen in most countries. Prevention of further excess weight gain can thus be accomplished with relatively small changes, on the order of 10's of kcals/day.[25] However, population weight has been accumulating in most countries for decades, [27] and higher weights require greater energy intake to maintain. Thus a much larger "Maintenance Energy Gap" needs to be overcome,[25] which can be viewed as the energy needed to both stop gaining additional weight and that needed to lose a specified level of excess weight. For example, the Healthy People 2010 goal in the United States was to reduce excess weight levels to those found in 1970.[70] With this goal, the "Maintenance Energy Gap" for an average adult in the US currently amounts to about 1 MJ/d (240 kcal/d). For adults with a BMI of 35 or more (currently 14% of adults[71]), more than double this change is required.[25]

Thus it is important for countries to focus on prevention, as it becomes increasingly more difficult to reverse obesity trends as excess weight accumulates. Children are a particularly important focus for action because they have accumulated little excess weight, and thus small changes are an effective strategy.[72] Large energy balance changes also require a longer time to accomplish if sequential smaller changes are involved. Since political timetables often demand quick results, support may be difficult to generate if interventions take years to show effect. The energy gap framework can also assist by quantifying the impact of different preventive actions: e.g. calculations indicate a typical 9-year-old boy weighing 30 kg burns an extra 630 kj (150 kcal) by replacing 1.9 hours of sitting with 1.9 hours of walking; this is equivalent to replacing one can of sugar sweetened beverage with water.[72]

Cost Effectiveness of Obesity Interventions: the ACE Studies

The Australian Assessing Cost-Effectiveness (ACE) in Obesity[73] and ACE Prevention studies[74] are examples of integrative modeling strategies that bring together a broad range of evidence for informing resource allocation decisions. Details of intervention selection, modeling of intervention implementation, costing of intervention and associated cost-offsets, and the simulation models used are published elsewhere.[75,76] These studies evaluated preventive and treatment interventions for obesity: 11 among children and youth and 9 among adults. Interventions were modeled using local data and consistent methodology to facilitate cost-effectiveness ranking.[73] Interventions were reviewed by a stakeholder group to assess strength of evidence, effects on equity, acceptability to stakeholders, feasibility of implementation, affordability and sustainability, each which can impact policy decisions.[73,74]

The results – expressed as a cost per DALY averted – are presented in Table 1. Strength of evidence for effectiveness is ranked from 1 to 5, following the classification used in ACE[74] and building on other research.[68,77–80] Levels 1 and 2 indicate evidence is sufficient for decision making, and is generally based on interventions including RCTs and robust evaluations of policies. Those rated 3 or 4 do not provide such clear evidence, and 5 indicates inadequate or inconclusive evidence. Studies assumed a decision threshold of AUD 50,000 (US 49,500) per DALY prevented to determine whether an intervention was cost-effective or not, reflecting empirical evidence on what constitutes acceptable value-for money in Australia.[81, 82] Use of standardized methods enhances comparability of results, although lower strength of evidence for many interventions limits the generalizability of findings, and costs can vary.

Eight of the twenty interventions were found to be both health improving and cost saving (“dominant”). Three were very cost-effective in that they improved health at a cost of less than AUD10, 000 per DALY prevented; three improved health at a cost of between AUD10,000-AUD50,000 per DALY prevented. The first 11 interventions in Table 1 (8 dominant and 3 highly cost-effective) should only be ignored if decision-makers have serious reservations about the evidence base, or are faced with insurmountable problems in relation to other considerations such as their implementation feasibility, equity impacts or acceptability to stakeholders.

The top three cost-saving interventions are environmental. They show modest effects at an individual level but prove highly cost-effective, because benefits accrue to the entire population and cost of implementation is relatively low.[77] However, these interventions differ in terms of the sufficiency of evidence related to their effectiveness and differences in the additional filters. For example, while reduction of TV 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, making implementation highly unlikely.[83] The evidence around front-of-pack traffic light nutrition labeling was considered insufficient to warrant policymaker support at this time in Australia, despite plausible assumptions.[84]

An overriding conclusion of the ACE evaluations is that policy approaches generally show greater cost-effectiveness than health promotion or clinical interventions. This conclusion is borne out by other studies. For example, regulatory and fiscal interventions (e.g. regulation of food advertising to children) were the least expensive measures among those examined by OECD. They argued that fiscal measures were the only interventions likely to pay for themselves, i.e. they were likely to generate larger savings in health expenditure than costs of delivery.[85]

Translation of Cost-Effectiveness Results to Other Settings

Translating ACE findings into practice in a particular country may require modifications. For example, an "unhealthy food and beverage tax (10%)" has not been a strong focus in the United States, but an excise tax on sugar sweetened beverages (SSB) has received much discussion. The evidence base for an SSB intervention in reducing excess caloric intake and weight is reasonably strong,[86] intake is high,[87,88] and a tax can raise billions of dollars ($US) per year for cash starved states.[89] Different tax structures mean 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 US has a high level of television advertising (18 minutes per hour), but freedom of speech issues limit regulatory options. Nevertheless, limiting the corporate tax deductibility of advertising costs for unhealthy foods may be a politically feasible option.[90]

Some community based program interventions were found to be cost-effective in both ACE and OECD studies, but effects often depend on sustained public funding. Many programs are confined to specific target populations, limiting the beneficiaries. For example, some clinical interventions offer large benefits to individuals, but apply to relatively small populations.

Similar modeling exercises have been used by others. As policy makers wrestle with limited budgets, the ability to demonstrate cost-effectiveness is in great demand. Foresight[21] conducted analyses useful to the cross government strategy Healthy Weight Healthy Lives in England. OECD models of multiple interventions have informed government planning in high[85,91] and low and middle income countries.[92] The National Institute for Health and Clinical Excellence (NICE) has published cost effectiveness studies of health care interventions[93,94] as has the Dutch Centre for Public Health and the Environment.[95]

Thus, there are cost-effective interventions that can lower obesity prevalence and improve long term health and economic outcomes. However, even the most effective interventions will not be sufficient individually to reverse the obesity epidemic. Solutions need to be multi-faceted, with initiatives at different levels of government and across multiple sectors. Interventions that may be quite modest in terms of their impact when assessed in isolation may still constitute important components of an overall strategy. An additional challenge for low and middle income countries is the continuing dual-burden of both undernutrition and obesity.[58]

The most cost effective interventions evaluated to date largely fall within the realm of fiscal and regulatory actions. It appears that analogous strategies that worked to restrict tobacco may prove useful to reduce obesity.[5,6]

A systems approach to obesity prevention – implications for policy-makers

A recent Institute of Medicine (IOM) Panel on evidence and obesity decision-making outlined the need for consideration of a broad range of evidence and for utilizing a systems perspective.[64] New thinking, new tools and the use of computational modelling methods are needed to facilitate a better understanding of the interconnectedness and synergies of the whole system, as well as of its individual components or sub-systems. What are the implications of a systems approach for decision-makers and policy development around obesity prevention? The IOM report borrowed from the Foresight strategic framework [21] to articulate major implications for policy-making.[64] These are shown in Panel 2 with examples and an additional call for linking with other major societal challenges.

Call to Action

United Nations (UN) Member States will gather in New York in September 2011 for the first High-Level Meeting of the UN General Assembly focused on non-communicable diseases (NCDs). The global obesity epidemic, which has been described as a 'wicked problem' because of its inherent complex and intractable nature,[96] will be the toughest challenge facing Member States since none has turned their obesity epidemic around. The UN meeting is in response to the overwhelming need for action on NCDs as a barrier to development in low and middle income countries. Obesity prevention is a major part of that effort. Important questions include: what actions are needed and what can be implemented?

WHO's Global Strategy on Diet, Physical Activity and Health[47] provides a framework for action on both child and adult obesity prevention that is linked to other WHO strategies such as prevention of NCDs.[97] The Global Strategy framework has a long list of policy areas for action because it encompasses multiple levels of jurisdiction across a wide range of policies for health services, health promotion programs, and improved environments related to food, physical activity and the socio-economic determinants of health.[98,99] A number of authoritative reports have developed priority actions needed for key actors at the global and national levels.[47,100–105] There is strong consistency across these recommendations, although many are necessarily broad to accommodate different contexts.

Recommendations for obesity prevention tend to fall into two broad categories of actions: 'direct' actions to impact energy balance, and more indirect 'structural' actions which support direct action. Direct actions have logic pathways from intervention to energy balance. Recent research has documented cost-effectiveness for many potential direct actions (e.g. Table 1 and [85, 91–95]). A systems approach, however, reminds us of the critical importance of 'structural' or cross-cutting interventions which provide support for direct action but for which cost-effectiveness evidence is often not available (e.g. what is the cost-effectiveness of an obesity monitoring system?) Just as a house needs plumbing and electricity structures to work, so an obesity prevention plan needs structural actions in place for direct actions to work. This is an especially important message for low and middle income countries which need to boost structures supporting workforce skills, knowledge creation and exchange for public health in general. Most countries still lack even basic data, with only one third of European Union countries having nationally representative data on children's weight and height.[106] 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 on obesity is also low in many countries with the First Lady Obama in the United States showing the value of high level attention to the issue.[107] In the following sections, we discuss progress and contributions of each of 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. While the consequences of obesity mainly burden the health system, ministries outside health, such as finance, education, agriculture, transportation and urban planning arguably have the greatest influence in creating environments conducive to obesity prevention.

While many governments have developed guidelines and strategic plans to improve dietary and physical activity patterns, translating these plans into action has been disappointing. Almost all food policies recommended as priority actions, including regulations to restrict food and beverage marketing to children, front-of-pack traffic light labelling, and sugar-

sweetened beverage taxes, have been heavily contested by the food industry making implementation politically difficult. A number of these direct actions are now well supported by cost-effectiveness evidence. 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. For example, the single major investment in obesity prevention by the recent Howard Government in Australia was AUD214 million for an active after-school program[108] which was not even recommended by the government's own National Obesity Taskforce.[109]

Actions recommended by WHO and other authoritative groups[47, 100–105] for governments are grouped into core actions in Panel 3 with concrete examples for each.

International agencies

Many international agencies affect food and public health, and national governments are usually the major stakeholders and funders of these bodies. The United Nations (UN) has several core agencies directly involved in health and development including the World Health Organisation (WHO), Food and Agriculture Organisation (FAO), UN Children's Fund (UNICEF), UN Development Programme (UNDP) and the World Food Programme, as well as inter-agency bodies such as the Standing Committee on Nutrition and Codex Alimentarius Commission. All have critical roles to play in international leadership, standard setting, and creating collective agreements of national governments. Despite 60% of the global mortality coming from NCDs and 80% of the premature NCD mortality being from low and middle income countries,[110] 12% of the WHO budget is allocated to NCDs.[111]

Also powerful are the political, economic and trade related multi-national bodies including the World Trade Organisation (WTO), the World Bank, International Monetary Fund (IMF), European Union (EU) and the informal groups: G8, G20 and G70. While the primary concerns of these groups are not public health, their actions can have profound effects on public health, including obesity and chronic disease, and public health can have a profound effect on the economy of nations.

Key actions needed are in Panel 4. The UN High Level Meeting in September 2011 will be an important opportunity for Member States to demonstrate the international leadership needed for a global effort to reduce obesity and NCDs. The litmus test beyond that meeting will be how well Member States match their declarations with supportive funding and policies to support global actions. The UN Standing Committee on Nutrition is the coordinating body for food and nutrition activities across UN agencies, but in 2010 almost closed due to lack of funding. This coordination role is vital and needs support.

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. They shape food and activity environments we live in and, through communications and marketing, also shape people's perceptions, desires and accepted norms. Their active support is needed to reduce obesogenic environments. The food and beverage industries, in particular, have taken steps in recent years as individual companies and through representative organizations to respond to the obesity epidemic.[112] While they have been criticized for their part in creating obesogenic food environments, they clearly have the collective power to make those same environments less obesogenic. Whether various actions and pledges by food and beverage industries can reduce obesity is uncertain, and rigorous independent evaluation is needed. The most powerful activities by the private sector relevant

to the formulation of public policy is undoubtedly lobbying activities. These often undermine policies aimed at reducing obesity, e.g. in relation to regulations on marketing to children, traffic light labelling, and taxes on unhealthy foods.

Civil society

Civil society organizations include public interest and consumer associations, charitable organizations, academic institutions, foundations, professional associations, and other community, religious, and advocacy groups. While they have limited funding and hold less power than other actors, they fill important advocacy and 'watchdog' roles. They tend to be in the forefront of calling for healthy, sustainable and fair environments, although in some non-democratic countries their freedom to speak out for change is significantly curtailed. In general, advocacy activity in low and middle income countries is limited and global non governmental organizations (NGO)s can play an important supporting role.

Health professionals

There is some evidence for physician counseling as effective in supporting patients to improve diet and physical activity and lose weight.[93,94]

Individuals

The final choices for eating and physical activity behaviours rest with individuals although available choices to them may already have been 'edited' depending on the settings. Parents and caregiverss have particular responsibilities and greatest opportunities to promote life-long healthy behaviours among children and adolescents. All individuals can influence their own home environment as well as other settings in which they interact on a regular basis such as schools, workplaces, sports clubs, churches and community organisations (Panel 4).

Conclusion

This Series of papers in the Lancet documents the growth of an emerging science of obesity prevention and control. The obesity epidemics in countries throughout the world are driven by a complex of forces that require systems thinking to conceptualize the drivers of the problem and to organize evidence needed for action. Applications of quantitative modeling have made it possible both to plan for and to evaluate the impact of actions to prevent and control obesity. These 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 programs and policies. A rapid scaling up of efforts is needed. The UN High Level Meeting on NCDs in September 2011 provides a key opportunity to strengthen international leadership from the UN and its agencies, as well as to galvanize other agencies and states to begin to seriously address the continuing global epidemic of obesity.

Key messages

- Childhood and adult obesity is increasing in high, middle and low income countries. Mounting evidence links obesity to short and long term health, social and economic consequences.
- Empirical evidence of 'what works' to prevent obesity is limited but growing. The evidence base needs to be broadened beyond randomized controlled trials to include evaluation of natural experiments, policy changes and costs.
- Mathematical modelling is providing 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 of analyses of policies and programs indicate several to be both effective and cost-saving.
- The application of a systems approach to obesity prevention is new but already has policy implications including: the need for multiple actions especially in non-health sectors, investments in cross-cutting support systems, policies which target the food and built environments, and additional data for forecasts and evaluation.
- Governments need to be lead players in obesity prevention, but few have shown leadership to date. The food industry has been very active through various 'pledges', self-regulatory codes and product reformulation, although the impact of these changes need to be independently evaluated.
- 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 which provides both a healthy and a secure food supply for all.

Panel 2: Implications of a systems approach for policy-makers, adapted from [64]

- **Systematic change that addresses the diverse determinants of obesity simultaneously to minimize risk of compensatory actions**. A comprehensive approach with strategies will be needed to address the main drivers of the epidemic, so that, for example, a narrow ban on food advertising during designated children's television programs does not result in increased advertising in other programs that children watch.
- **Integrated interventions at all levels of society – individual, family, local, national, national and international – recognizing that individual choices are shaped by the wider context**. Solutions will cover multiple jurisdictions and a wide range of players across all levels of society. Core investments need to be made in coordination, networking, and communications to maximize impact.
- **Interventions across the life course to reinforce and sustain long-term behavioural change**. Interventions should be integrated and address all age and demographic groups.
- **Diverse interventions that combine 'direct' initiatives (which influence energy balance), 'structural' actions (which inform and facilitate change and indirectly influence energy balance), and 'amplifiers' (which address social norms and other contexts)**. While only direct interventions are amenable to cost-effective analyses, best practice public health requires a mix of all three types of intervention.
- **Actions planned over time such that early initiatives build a climate for subsequent interventions**. While early interventions may be visible but limited, they are the platform to achieve more comprehensive, systems-oriented actions.

- **Ongoing research and evidence gathering, including population level monitoring and evaluation of interventions**. While traditionally poorly funded by governments, measuring problems and identifying solutions is essential.
- **Obesity should be linked to other major issues confronting societies**. Promoting development in low and middle income countries, reducing poverty in all countries, creating a sustainable food supply, and combating climate change all have strong links with obesity prevention with some common drivers and solutions.

Panel 3: Core actions for governments to reduce obesity prevalence

Underpinning 'structural' actions create stronger prevention systems to support specific 'direct' actions to reduce obesity.

Leadership and governance

- High level political leaders (prime ministers, presidents, ministers) demonstrate leadership by supporting actions to reduce obesity
- Cross-sectoral structures are in place to ensure support of high-level leadership
- Mechanisms are in place to limit influence of commercial interests in policy-making

Health-in-all policies

- The protection and promotion of health and sustainable food security are over-riding priorities in food policy development
- The protection and promotion of health is ensured in trade agreements and agricultural and food fiscal policies (e.g. subsidies, taxes, import tariffs, quotas)
- Transport and urban planning policies and budget allocations place a priority on public transport, walking/cycling environments, safe recreation spaces
- Taxation and social policies support the reduction of socioeconomic inequalities which contribute to health inequalities

Resourcing

- Commit funding for preventive health including targeted effective 'direct' and 'structural' actions
- Health promotion activities are included within other existing budgets (e.g. treatment services, education, local government)
- Health promotion foundations are established and funded through taxes on tobacco, alcohol or unhealthy food and beverages

Intelligence systems (monitoring, evaluation, research, and knowledge exchange)

- Monitoring systems are in place to track obesity trends in children and adults as well as key aspects of the food and physical activity environments (e.g. nutrient composition of foods, exposure of children to marketing)
- Centers with expertise in obesity prevention research and evaluation are identified and supported within academic institutions
- Knowledge exchange mechanisms are in place to share evidence and experiences

Policy implementation support systems

- Nutrient profiling systems are adopted to underpin food and nutrition policies (e.g. front-of-pack traffic light labelling, regulations on marketing to children)
- Systems are in place to support the implementation of healthy food service policies by public and private sector organisations and support for physical activity
- Standards and guidelines for local authorities to create environments for active transport and recreation

Workforce capacity and development

- Sufficient, skilled staff are employed within the prevention workforce
- Nutrition, physical activity and the prevention of obesity are prominent within curricula for health and related professionals (e.g. planners, teachers, child care workers)
- Quality postgraduate courses, including PhD opportunities, are available for low and middle income countries

Partnerships, organizational relationships and networks for coordination

- Cross-sectoral structures are in place at the national/state level to coordinate activities across the government, non-governmental organizations and private sectors
- Partnership/coordination structures are in place at the local level to plan and coordinate local action on healthy food and physical activity environments

Communications (including social marketing)

- National guidelines for individuals on healthy eating and physical activity are available, communicated and regularly updated
- National targets for the food industry on food composition, marketing to children, and food claims are established and communicated
- Effective social marketing communications provide consistent messages that motivate individuals to adopt healthy lifestyles and create healthy environments for others, especially children

Panel 4: Key actions needed from international agencies, the private sector, civil society, health professionals and individuals

International Agencies

- **Leadership:** The UN, its Member States, and agencies provide global leadership through commitments for increased funding and policy support for prevention of obesity and NCDs
- **Health in policies:** All international agencies ensure that protection and maintenance of public health is built into all relevant trade, economic, agriculture, environment, food and health agreements and policies
- **Funding and coordination:** The UN ensures that policies and funding to prevent obesity and NCDs are implemented and coordinated across its agencies

- **Standards and codes:** WHO develops global standards, particularly for food and beverage marketing to children and nutrient profiling

Private Sector

- **Reformulation:** Processed food and beverage industries reformulate existing products and develop new products with healthier nutrient compositions, particularly though feasible reductions in sugar, salt, unhealthy fat and energy density
- **Marketing:** Food and beverage and communications industries apply voluntary restrictions on all forms of marketing promotions of foods high in sugar, salt and unhealthy fat to children and adolescents
- **Labelling:** Food and beverage industries and food retailers ensure food labelling, packaging and health claims meet high standards in all countries
- **Other commercial influence activities:** The private sector uses all available strategies to support public health efforts to create healthier food systems
- **Monitoring:** Relevant industries support efforts to monitor progress towards healthier food systems by sharing relevant data to protect commercially sensitive information and help governments evaluate progress towards targets

Civil Society

- **Advocacy:** Form alliances and networks to share information, build the constituency for change, and advocate for the policies and programs to reduce obesity
- **Monitoring:** Monitor policies and practices of the other actors and hold them to account for their actions, inactions or counter actions in relation to efforts to promote healthier environments and reduce obesity and chronic disease

Health professionals

- Monitor the weight of patients and offer suitable evidence-informed advice about maintaining a healthy body weight
- Provide ongoing support (or refer for support) those patients ready to undertake a weight loss program

Individuals

- For parents and caretakers, act as role models for health-promoting behaviours for children and adolescents
- For individuals, make personal healthy food and activity choices
- For individuals, help create healthy food and physical activity environments in homes and other settings

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Table 1

Cost-effectiveness results for selected interventions evaluated in Australia

Intervention	Target population	Strength of evidence[1] 1=strongest	DALYs[2] saved	Gross costs[3] (AUD[4] million)	Net cost per DALY saved[5] (AUD[3] million)
Unhealthy food and beverage tax (10%) *[84]	Adults	4	170,000	1	Cost-saving[6]
Reduction of advertising of 'junk food and beverages to children'#	Children age 0– 14	2	37,000	0.13	Cost-saving
Front-of-pack traffic light nutrition labelling *[84]	Adults	5	32,000	4	Cost-saving
School-based education program to reduce TV viewing#	Primary school children (8–10)	3	8,600	27.7	Cost-saving
Multi-faceted school-based program including nutrition and physical activity#	Primary school children (age 6)	3	8,000	40	Cost-saving
School-based education program to reduce sugar sweetened drink consumption#	Primary school children (7–11)	3	5,300	3.3	Cost-saving
Family based targeted program for obese children#	Obese children (ages 10–11)	1	2,700	11	Cost-saving
Multi-faceted targeted school-based program#	Overweight/obese primary school children (ages 7–10)	3	270	0.56	Cost-saving
Gastric banding - adolescents#[113]	Severely obese adolescents (ages 14–19)	1	12,300	130	4,400
Family-based GP-mediated program#[114]	Overweight/ moderately obese children (ages 5–9)	3	510	6.3	4,700
Gastric banding – adults *	Adults BMI>35	1	140,000	120	5,800
Multi-faceted school-based program without an active physical activity component#	Primary school children (age 6)	3	1,600	51.2	21,300
Diet and exercise *	Adults BMI >25	1	3,000	140	28,000
Low fat diet *	Adults BMI>25	1	1,900	94	37,000
Active After Schools Communities Program#[115]	Primary school children (5–11)	5	450	40.3	82,000
Weight Watchers *	Adults	1	54	5	84,000
Lighten Up to a Healthy Lifestyle weight loss program *	Adults	4	38	4	94,000
TravelSMART Schools#	Primary school children (ages 10–11)	4	90	13.1	117,000
Orlistat *	Adults BMI>30	1	2,100	1,500	700,000
Walking School Bus#	Primary school children (ages 5–7)	3	450	40.3	760,000

* Interventions drawn from ACE-Prevention study 2010.[74]

[#] Interventions drawn from Ace-Obesity study.[73]

[1] This classification (1 = strongest; 5 = weakest) is based on criteria adopted in ACE-Prevention.[74] 1) 'Sufficient evidence of effectiveness' Effectiveness is demonstrated by sufficient evidence from well-designed research that the effect: is unlikely to be due to chance (e.g. $p<0.05$); and is unlikely to be due to bias, e.g. 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 program logic; and level IV studies, indirect or parallel evidence for outcomes; or epidemiological modeling 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 II studies) 4) 'May be effective' is similar to 2) but with potential lack of significance and confounding. 5) inconclusive or inadequate evidence (5 or 6 in original studies).

[2] DALYs = Disability-adjusted life years saved which combine premature death (years of life lost) and morbidity (years lived with a disability)

[3] Gross costs = intervention costs

[4] AUD = Australian dollars (1 AUD=0.998 US)

[5] Net cost per DALY saved = Gross costs minus cost offsets divided by number of DALYs saved

[6] Cost-saving = achieves both health gain and cost savings ("dominant")