**Correspondence**
Tai Hing Lam
School of Public Health, The University of Hong Kong
G/F Patrick Manson Building, 7 Sassoon Road, Pok Fu Lam, Hong Kong SAR, China.
Tel.: +852 3917 9287
Fax: +852 2855 9528
Email: hrmrlth@hku.hk
Received: 3 August 2017; revised 8 January; accepted 23 January 2018


**Review Article**

# Stage of obesity epidemic model: Learning from tobacco control and advocacy for a framework convention on obesity control

Highlights:

- A stage of obesity epidemic model is proposed to forewarn the expanding obesity problems and the challenges in epidemiology and interventions.
- Obesity is at the early stages (Stage 1 or 2) in most countries with increasing prevalence. All the adverse health effects due to obesity have not manifested and cannot be shown by existing studies.
- We advocate for a framework convention on obesity control.
- Healthcare professionals should take leading roles in public health advocacy and clinical practice on weight control.

Lin XU[1,2] and Tai Hing LAM[2,3]

[1]School of Public Health, Sun Yat-sen University, Guangzhou, Guangdong, China
[2]School of Public Health, The University of Hong Kong, Hong Kong SAR, China
[3]Guangzhou 12th Hospital, Guangzhou, China

**Abstract**

The 2011 United Nations political declaration against non-communicable diseases (NCDs) targeted four major risk factors: tobacco use, harmful use of alcohol, an unhealthy diet, and a lack of physical activity. The Framework Convention on Tobacco Control (FCTC), MPOWER strategies, and the four-stage model of the tobacco epidemic are useful references for the prevention and control of other risk factors and NCDs. Obesity control is a more complex challenge. Herein we propose a stage of obesity epidemic model (SOEM). Obesity is in the early stages in most countries with increasing prevalence, but its effects on mortality will increase rapidly, even if its prevalence may have reached a peak and be declining. Based on current relative risk, obesity kills one in three obese people. Like tobacco, epidemiological studies of obesity in the early stages would underestimate the risks and disease burden. Further research will reveal more harm, especially from long-term obesity since childhood. The prevalence of obesity will likely overtake smoking prevalence, but commitments to obesity control are too weak. The SOEM is needed and should be useful to forewarn against the expanding public health problems attributable to obesity, and challenges in epidemiology and interventions. Learning from tobacco control, we advocate for a framework convention on obesity control. Framing obesity control initiatives in the spirit of MPOWER strategies against tobacco should be considered to prevent and control obesity and obesity-induced diseases. Healthcare professionals should take leading roles in these initiatives and obese individuals should reduce their weight and 'quit' obesity.

**Keywords:** mortality, obesity, prevalence, stage of obesity epidemic model.

## <A>Introduction

The 2011 United Nations Political Declaration against four non-communicable diseases (NCDs) (Accessed online at http://www.who.int/nmh/events/un_ncd_summit2011/en/ on 8 Feb. 2018), namely cancer, cardiovascular disease, chronic respiratory disease, and diabetes, targeted four major risk factors: tobacco use, harmful use of alcohol, an unhealthy diet, and a lack of physical activity. Of the four risk factors, smoking is widely considered as the single most important avoidable cause of death. Tobacco control has the longest history and is leading NCD control with the Framework Convention on Tobacco Control (FCTC; accessed online at http://www.who.int/fctc/en/ on 8 Feb. 2018) and the evidence-based effective

MPOWER strategies (Accessed online at www.who.int/tobacco/mpower/en/ on 8 Feb. 2018). Tobacco control has also resulted in major achievements. In some developed countries, as well as in middle-income countries, smoking prevalence has been steadily declining, followed, approximately three decades later, by declines in smoking-induced diseases and mortality.[1,2] In contrast, the prevalence of obesity and overweight is rising globally, and is becoming an expanding epidemic.[3] There is growing evidence that obesity is currently the second-most important health problem after smoking. A recent World Health Organization (WHO) report showed that globally, in 2014, 39% of adults aged ≥18 years were overweight, and more than half a billion adults (11% of men and 15% of women) were obese (Accessed online at http://www.who.int/mediacentre/factsheets/fs311/en/ on 8 Feb. 2018). Obesity was associated with approximately one-fifth of all deaths in US adults from 1986 to 2006.[4] The more recent the birth year, the greater the effect obesity has on mortality rates.[4] With further advances in tobacco control, obesity may overtake smoking as the most important and avoidable cause of morbidity and mortality.

Both obesity and smoking are major causes of NCDs but, unlike smoking, obesity can be categorized as a risk factor or as a condition or a health outcome. Long-term information on obesity and risk of NCDs attributable to obesity is not available for many countries given the difficulties in measuring obesity using different measures and definitions, and the fluctuation in weight during the life course. Moreover, similar to smoking, the duration of exposure to obesity has been reported to have an important effect on mortality, although research results remain scarce.[5] Hence, the full deleterious effect of recent obesity on mortality may not have emerged and cannot be revealed by existing studies. Due to the long latency of a few decades, a higher mortality risk due to obesity would be expected in cohorts established decades ago if they are to be followed-up for a few more decades, even if the current patterns of obesity remain. If the prevalence of obesity is increasing, all current risk estimates or risk projections are likely to be underestimates. Until we can see a declining trend of mortality due to obesity, we do not know when the peak will appear. And unless epidemiology can catch up with the evolving risk factor–disease outcome relationships, we do not know what the maximum risks and disease burdens that can be attributed to obesity. Hence, we propose a four-stage obesity epidemic model, with reference to the model for tobacco.

The four stages of the tobacco epidemic model were first introduced by Lopez et al. in 1994.[6] This tobacco epidemic model has four curves: two on prevalence and two on the percentage of deaths attributable to tobacco, by sex. According to the tobacco epidemic

model, smoking prevalence grows slowly in the first 20 years (Stage 1), steeply in the following 30 years (Stage 2) and peaks at the end of Stage 2 to a prevalence of 60%. Then, the epidemic starts to decline gradually, by approximately 0.5 percentage point per year in Stage 3 and by 0.75 percentage point per year in the final stage.[6] The most remarkable feature of this model is the gap of 30 years between the peak in smoking prevalence and the peak in the percentage of deaths due to smoking. Assuming the obesity epidemic will behave similar to the tobacco epidemic, we used the prevalence of obesity and percentage deaths attributable to obesity to propose and construct a stage of obesity epidemic model (SOEM).[7] The similarities between tobacco and obesity, as well as some differences, are discussed below.

The first similarity between tobacco and obesity is the continuously increasing trend within the first several decades of the epidemic, with tobacco starting early, followed by obesity a few decades later, without signs of falling in the early stages. Second, obesity is a major cause of NCDs. Among the four major risk factors for NCDs, except for tobacco use, three are related to obesity, namely the harmful use of alcohol, an unhealthy diet, and a lack of physical activity, highlighting the need for better understanding of the evolution of the obesity epidemic for NCD control. Third, unlike the benefits of quitting smoking, which have been clearly demonstrated in the later stages of the tobacco epidemic, sustainable weight reduction and "obesity cessation" at the population level has not been evident, but the benefits can be expected or hypothesized.[8] Although considerable advances have been made in diet, exercise, and behavioural approaches, as well as in medical treatment for obesity, such advances have not yet shown a marked effect on reducing mortality risk at the population level. Results from cohort studies showing mortality reduction due to healthy weight reduction are scarce,[1] and a meta-analysis reporting that weight reduction could be harmful is unexpected and problematic,[7] with the findings probably due to reverse causality and requiring careful interpretation. Fourth, in the early stages, like smoking, most of the information about obesity has come from studies in developed countries. But because developing countries have only recently experienced a short period of the obesity epidemic, the public health or population effects of obesity on chronic diseases or mortality have not been fully revealed by existing studies. However, examining the harms on the disease burden and mortality in developed countries is of worldwide relevance in predicting future effects in countries in the early stages, and can provide a unique opportunity for taking preventive actions and evaluating the benefits of such actions. However, studies from low- and middle-income countries are also needed for monitoring the increasing epidemic. Fifth, although obesity is also largely preventable by public health measures and individual lifestyle changes,

more and stronger actions are needed for sustainable obesity reduction in the population. Sixth, smoking and obesity are both population problems rather than just individual problems. Effective prevention and management of obesity requires a multidisciplinary approach and comprehensive measures, involving actions in all sectors of society and united global actions. Obesity control must learn from the experience and achievements in tobacco control. Seventh, obesity affects all age groups and both sexes, with smaller sex differences than smoking. Effective obesity prevention strategies must be implemented earlier, probably from infancy and childhood. Based on the most recent data from the Global Burden of Disease Study,[3] defining and identifying the extent of the problem of obesity is a critical first step in a coherent approach to its prevention and management. The SOEM would add to what we would predict or expect in the next few decades, particularly in warning about the gaps of several decades before the arrival of the peak of mortality. Furthermore, unlike smoking, which has only one dimension, obesity problems in low-to-middle income countries (LMICs) may coexist with problems of undernutrition or malnutrition, and tackling obesity issues is much more complex.

**<A>Model characteristics**

Similar to the tobacco epidemic model, four stages are proposed for the SOEM. Obesity is simply defined as a disease in which excess body fat has accumulated to such an extent that health may be adversely affected.[9] Body mass index (BMI) is the most widely used, albeit crude, measure of obesity. A BMI of ≥30 kg/m$^2$ is often used to define obesity.[9] The prevalence would be greater if the definition of obesity includes both general and central obesity. Unlike smoking, because of the lack of substantial sex differences in the trends of obesity prevalence and the percentage of mortality attributable to obesity, the SOEM does not show the sexes separately. The principal characteristics of each stage of the SOME are summarized below.

**<B>*Stage 1: Prevalence of obesity up to 20%, 5% deaths; 30 years***

Stage 1 is the very beginning of the obesity epidemic in a population. The prevalence of obesity is relatively low (<20%), and the deaths and diseases due to obesity in this stage are not yet evident (<5%). Such an initial stage is proposed to be short, perhaps less than three decades. Most of the countries in South or East Asia, such as China, Korea, and Japan, are now at this stage, showing an obesity prevalence <20% and an obesity-attributed mortality of <5%.[3,10]

**<B>*Stage 2: Rapid increase in obesity to a peak of 60%, 10% deaths; 30 years***

During Stage 2 of the epidemic, which may span 3 decades, the prevalence of obesity continues to rise rapidly, reaching a peak of approximately 60%. Population-based obesity control strategies have been implemented to varying extents but have not succeeded in reducing the prevalence of obesity. During this stage, the percentage of obesity-attributed deaths increases up to 10%. The US is now at early Stage 2, whereas some countries have already reached late Stage 2, such as Tonga and Samoa, which had an obesity prevalence of 60% and 58%, respectively, in 2013.[3] In 2013, the Member States of the World Health Organization (WHO) introduced a voluntary target to stop or reverse the rise in obesity by 2025, which means that peak obesity prevalence has not yet been reached and hence most, if not all, countries are at Stage 1 or 2.[11]

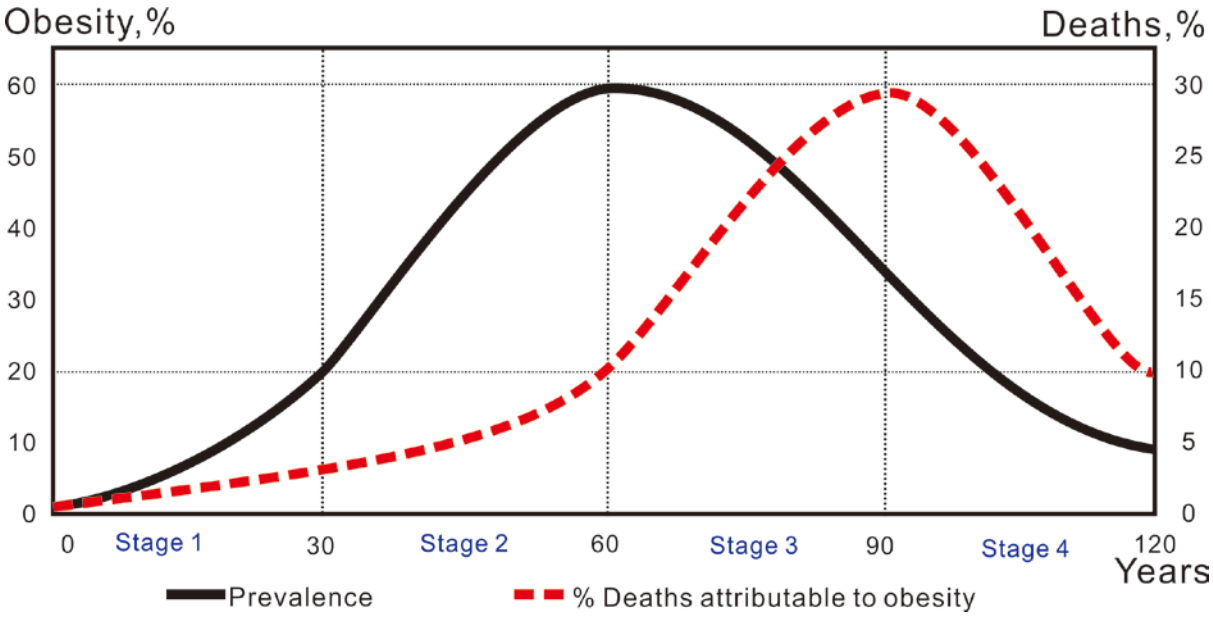
**<B>*Stage 3: Downturn in obesity to 30%, deaths peak at 30%; 30 years***

By the end of Stage 3, which may last for approximately three decades, the prevalence of obesity begins to decline to around 30% (i.e. a reduction by 30 percentage points or by half the peak prevalence). The most dominant characteristic of this phase is the rapid rise in obesity-attributed mortality, from 10% to approximately 30%, despite the decline in obesity prevalence. Like tobacco, the gap of approximately three decades between the peak prevalence and peak proportionate mortality would lead to a misinterpretation of the paradox that obesity decline is followed by an increase in mortality attributed to obesity (hence misinterpreted as “obesity decline causes an increase in mortality”). By the end of this stage, mortality attributed to obesity has reached a peak. Although the alarm regarding the serious harms of obesity is reaching the highest levels, the paradox of decreasing prevalence and increasing mortality would lead to increasing doubts about the benefits of obesity reduction and obesity control measures. These can be true concerns or malicious arguments used by those with vested interests to fight against effective obesity control measures.

**<B>*Stage 4: Prevalence slowly decreasing to 5%, deaths decreasing rapidly to 10%; 30 years***

In Stage 4, obesity prevalence continues to decline, but more slowly, within a relatively wide span, perhaps three decades, with a range of 3–5 decades, probably reaching 5%. Meanwhile, the obesity-attributed mortality would continue to decline. By the end of this stage, the proportionate mortality from obesity would decrease rapidly by approximately 20 percentage

points to 10% (i.e. by two-thirds from the peak of 30%). This stage is most remarkable in showing the benefits of obesity control and obesity prevalence reduction.




**<A>Discussion**

**<B>*Relative and absolute risks of death from obesity***

Almost all populations in high-income countries and LMIC are in the early stages (Stage 1 and 2) of the obesity epidemic. Results in the literature of population-based cohort studies established a few decades ago may have reflected the mortality risk of people born a few more decades earlier and longer follow-up for a few decades more would reveal greater and the maximum relative risks from such cohorts. In populations in which the obesity epidemic is in the very early stage (Stage 1), because the prevalence of obesity is low and the duration of obesity in these cohorts is short, the obesity mortality risk is minimal (<10%). The obesity mortality risk shown in our SOEM is supported by a recent meta-analysis on individual participant data (which also showed increased mortality risk for overweight) after removing the effects of smoking or ill health on BMI.[12] That meta-analysis reported a relative risk (RR) of 1.44 for total mortality, which is the highest RR reported.[13] Based on the RR of 1.44,[12] we estimated an absolute risk attributed to obesity that approximately one in three people (based on [1.44 – 1]/1.44 = 31%) with obesity will be killed by obesity or die prematurely from obesity-related diseases.[14]

Hence, existing or recent cohort studies on obesity in populations with a low prevalence of obesity at baseline would have a short duration of obesity and/or short follow-up. Together

with reverse causality that illnesses would result in weight loss intentionally or unintentionally, all these would lead to underestimation of the obesity-attributed mortality risk, as shown in a previous meta-analysis that was based on averaged data.[13] The WHO does not have such absolute risks of death from obesity in obese people. We advocate that the warning that "Obesity kills up to one out of three obese people" should be widely publicized as a public health alarm, which should be striking to the public and policy makers. Note that this absolute risk could be an underestimate and should be reviewed and updated when new results are available, although this may take a few decades. The full impact of obesity (and overweight) on mortality can only be observed at Stages 3–4. Countries at Stage 1 are unlikely to take serious actions on obesity control. Our model should forewarn of the forthcoming expansion of the epidemic, and earlier actions would delay the increase and may prevent some obesity-induced disease and mortality burden.

**<B>*What would the SOEM contribute?***

The main values of the SOEM are to: (i) raise awareness and increase understanding that the obesity epidemic and the NCD mortality it causes will go through several stages; (ii) highlight that the current risks from cohort studies are underestimated in the present early stages, and that such consistent underestimation will continue for a few more decades; (iii) raise a strong alarm that worse health and economic consequences will come before we start to see the benefits of any clinical and public health interventions; (iv) highlight that early and strong obesity control measures are needed urgently, even if the benefits may not be observed until a few decades later; (v) highlight that there are many challenges in epidemiology and interventions against obesity and its risk factors and outcomes, and that we can learn from studies on tobacco control; and (vi) stimulate more research on obesity and obesity control. The Global Burden of Disease Study data suggest that, regardless of the definitions of obesity used, obesity prevalence is increasing worldwide at an alarming rate in both developed and developing countries.[3]

**<B>*The obesity epidemic is more complex than the tobacco epidemic***

Unlike smoking, there are further difficulties in constructing a more robust obesity epidemic model. Smoking can be classified simply into smokers or non-smokers (which is also an oversimplification, because heavy smokers have much higher risks than light smokers), but defining obesity into "yes" or "no" is more problematic. There is no consensus and one definition may not fit all. The definition of obesity based on a single point measure of BMI

and the term “general obesity” are also problematic. The use of BMI in distinguishing between overweight and obesity is particularly limited for individuals in the intermediate BMI range (25–30 kg/m$^2$), in men, and in older people.[15] This is also the case in individuals with a high muscle to body fat ratio and in certain ethnic groups.[16] The use of ethnic- or race-specific thresholds (i.e. BMI ≥30 kg/m$^2$ for Western populations and ≥28 kg/m$^2$ in China[17]) complicates this problem because the definitions are not determined a priori by exposure only, but are back-influenced by the health consequences of the exposure. This implies that the definitions will change as new health risks are detected at lower levels of adiposity and would vary as the risks vary in different populations. Second, self-reported measures, such as weight and height, are largely unreliable, compared with smoking.[18] Third, smoking is an addictive behavior, whereas obesity is the outcome of several behaviors. However, like smokers who should stop or reduce smoking and eventually quit, obese (and overweight) individuals should reduce their weight to normal or optimal (although the definitions may vary) and hence quit obesity. Although quitting smoking and quitting obesity are not identical, the latter can convey a clear message of stopping or getting rid of obesity. Hence, we recommend using the word “quitting” to emphasize the aim of changing from obesity to normal weight, for both individuals and public health. Fourth, most obesity cannot be “quit” or “stopped” at once to zero exposure as can smoking. However, similar to or worse than smoking, relapse is common after weight reduction interventions, and obesity can increase. Studies on “weight relapse”, weight change trajectories, and health consequences are scarce.[7] To date, no clear signs in declining obesity prevalence can be observed.[3,19] Hence, to monitor the obesity epidemic, both repeated cross-sectional surveys and very large population-based cohorts are needed periodically in regions at different stages of the obesity epidemic, with data collected using more standardized methods to allow for further consortium-based data integration and collaborative analysis process.

**<B>*Current efforts on “obesity control” are too weak***

The global emergence of the obesity epidemic has serious adverse health effects. The WHO Global Health Observation data show that at least 2.8 million deaths and 35.8 million of disability adjusted life years (DALYs) are attributable to adiposity each year globally.[20] More than 60% of global deaths are due to NCDs, and obesity is expected to overtake tobacco as the largest preventable cause of disease burden in the next few decades.[2] Although the reduction in premature deaths and disabilities from cardiovascular disease in developed countries has been declining for decades, the rise of obesity, type 2 diabetes mellitus, and

obesity-related cancers (e.g. breast, colon, prostate, endometrial, kidney, and gall bladder cancers) has been substantial.[22] The rapid expansion of the obesity epidemic is widely projected to continue to increase the burden of obesity-attributed mortality and morbidity in coming decades.[23,24] Although some countries have adopted national public health programs on obesity prevention,[25,26] whether these programs will have the anticipated population effect is yet to be determined.[27,28] Other strategies being considered by a few governments, such as taxation of select foods and beverages, particularly sugar-sweetened beverages,[29,30] are pioneering and promising. Like tobacco, increasing tax and price would likely to be the most effective measure, but will also be fiercely opposed by those with vested interests. The WHO target of a 0% increase in diabetes or obesity by 2025 is only voluntary,[11] meaning that the commitments globally, nationally, and individually are far too weak (and obviously much weaker compared with tobacco control) and that current efforts of obesity control are clearly not enough to lead to a decline in obesity in the near future, and certainly not before 2025. Without legally binding commitments and effective global intervention strategies for all countries, the prevalence of obesity in both children and adults will continue to increase, and this modest voluntary target of a 0% increase cannot be achieved.

**<B>*Advocacy for a framework convention***

The FCTC, effective from 2003, is the WHO's first international treaty targeting a public health risk factor. Much progress has been made globally. On obesity control, an editorial in *The Lancet* in 2011 criticized that: "*governments' actions are wholly inadequate…to change the obesogenic environment and reverse the current tsunami of risk factors*" and that self-regulation and voluntary agreements by the food and beverage industry do not work.[31] The editorial ended by stating, "*One immensely important next step in the fight against non-communicable diseases could be the agreement on a framework convention on obesity control*" and asking, "*Who will take the lead*?"[31]

In two major world conferences in 2014 (the International Congress on Obesity and UICC World Cancer Congress), we advocated for a framework convention on obesity control (FCOC) and that the MPOWER strategies for tobacco control should be adopted now for obesity control.[32,33] Here, we advocate for an FCOC, and that public health advocates should start the discussion. We suggest that the tobacco MPOWER strategies be considered for obesity control, and that various measures should be tested and evaluated. Greater investment into research on obesity and obesity control is needed to attract more and urgent attention to this serious problem. We suggest the following MPOWER obesity control strategies .

- First, monitor (**M**) obesity prevalence and prevention policies. The definition of obesity should be standardized and research on its health effects should be enhanced. The threshold values of defining different types of obesity and any obesity regardless of type may need to be revised when new or greater health risks from adiposity are revealed and confirmed. In addition to prevalence, more detailed information on other aspects of the epidemic, such as risk factors and causes of obesity, the duration of obesity, weight fluctuations and trajectories and the reasons for these, and obesity-related disease, is needed. We need a global adult obesity survey and a global youth obesity survey, like tobacco, plus a global children obesity survey starting from infancy. Large and representative population-based cohorts are essential for monitoring the increase in the absolute and relative risks of the obesity-related mortality and disease burden, and to quantify the benefits of prevention and obesity reduction. Moreover, all obesogenic industries and activities, and prevention policies, must be monitored.
- Second, to protect (**P**) people from obesity, exposures to the risk factors for obesity (primarily physical inactivity and an unhealthy diet), as well as to risk factors for the risk factors (e.g. promotion of sugary drinks) must be reduced. The effects of exposure to adult obesity on childhood obesity can be described as “passive obesity” when children become obese from overfeeding and/or following the example set by their obese parents or other obese adults, or being adversely influenced by the food industry and other vested interests.
- Third, the offer (**O**) help to quit smoking means that proactive efforts are essential and these efforts should also be a strategy to help people who are obese or overweight to “quit” obesity, or to help people who are normal weight to keep fit. Research of effective treatments in obese people is warranted, but new strategies are needed to help those who are only overweight.
- Fourth, warn (**W**) about the harms of obesity. Comprehensive and striking warnings like those of tobacco are rare, and public awareness is low. Nutritional labeling on foods does not warn against obesity and related diseases. Although most people know that smoking kills, few realize that obesity also kills. Raising awareness of the harms, especially on the absolute risk of death that one in three obese people will be killed by obesity or obesity-related diseases, would lead to stronger support from the public for more stringent obesity control policies and legislation.
- Fifth, enforcing (**E**) bans on the advertising and promotion of tobacco has been achieved

in most countries. But there is nothing like that for obesity control. Banning the sales of big soda from vending machines in schools have shown some progress.[34]

- Sixth, raising (**R**) taxes on obesogenic products, such as sugar-sweetened beverage[35,36] or saturated fat,[37] should be the most effective method to reduce consumption (or exposure), particularly in children. There is substantial evidence that taxing tobacco and alcohol products reduces smoking and drinking.[38,39]

**<B>*Health care providers should "quit" obesity***

In all public health campaigns, healthcare providers (HCPs) have always been the leading advocates and role models. Given the strong and aggressive opposition from many industries with different vested interests to fight against any effective obesity control measures, HCPs should be the first group to stop, get rid of or "quit" obesity. Learning from tobacco control again, British doctors were the first group of people to quit smoking after the British Doctors Study in the late 1950s showed that smoking can kill doctors.[3] In the case of obesity, HCPs should quit obesity immediately without waiting for similar evidence that obesity can kill HCPs. Prevalence data on overweight and obesity in HCPs are scarce and obesity surveys on HCPs, medical and other healthcare students are urgently needed. In addition, HCPs can be the most appropriate sentinel group for monitoring the obesity epidemic. Many HCPs have quit smoking, but those who continue to smoke show less support for tobacco control and smoking cessation.[40] Whether this is also true for obese HCPs is unknown. Studies on overweight and obese HCPs' attitudes and practices on their own obesity status, on weight or obesity control for their clients, and on public health would yield new knowledge to help them. Moreover, HCPs play an important role in providing counseling for overweight/obese people,[41] which is an increasing need[42,43] but currently largely underserved or almost ignored.[44] We do not know whether quitting obesity is easier or more difficult than quitting smoking, and comparative studies are interesting. Because weight reduction from overweight and obesity to normal weight would take a long time, HCPs' experiences of success or failure in quitting obesity would be invaluable to guide interventions in lay people. Hence, HCPs should take leading roles in both public health advocacy and clinical practice on weight control.

**<A>Conclusions**

The SOEM is needed and should be useful to forewarn against the expanding public health problems and challenges in epidemiological and other studies on or related to the obesity

epidemic. Healthcare professionals should take a leading role in the fight against obesity. To be good models for public health and clinical practices, obese individuals should reduce their weight now and “quit” obesity.

**<A>Disclosure**

None declared.

**<A>References**


1. Ng M, Freeman MK, Fleming TD, et al. Smoking prevalence and cigarette consumption in 187 countries, 1980–2012. *JAMA* 2014;311:183–192.
2. GBD 2015 Collaborators. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990–2015: A systematic analysis from the Global Burden of Disease Study 2015. *Lancet.* 2017;389:1885–1906.
3. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet.* 2014;384:766–781.
4. Masters RK, Reither EN, Powers DA, Yang YC, Burger AE, Link BG. The impact of obesity on US mortality levels: The importance of age and cohort factors in population estimates. *Am J Public Health.* 2013;103:1895–1901.
5. Abdullah A, Wolfe R, Stoelwinder JU, et al. The number of years lived with obesity and the risk of all-cause and cause-specific mortality. *Int J Epidemiol.* 2011;40:985–996.
6. Lopez AD, Collishaw NE, Piha T. A descriptive model of the cigarette epidemic in developed countries. *Tobacco control.* 1994;3:242-247.
7. Lam TH, Xu L. Commentary: Fundamental limitations of meta-analysis of cohort studies, epidemiological challenges and the stage of obesity epidemic. *Int J Epidemiol.* 2017;46:547–548.
8. Fildes A, Charlton J, Rudisill C, Littlejohns P, Prevost AT, Gulliford MC. Probability of an obese person attaining normal body weight: Cohort study using electronic health records. *Am J Public Health.* 2015;105:e54–59.
9. World Health Organization (WHO). *Obesity: Preventing and Managing the Global Epidemic.* Geneva: World Health Organization; 2000.
10. Xu L, Lam TH, Jiang CQ, et al. Changes in adiposity in an older Chinese population in rapid economic transition. *Obesity (Silver Spring).* 2016;24:2217–2223.

11. World Health Organization (WHO). Global action plan for the prevention and control of noncommunicable diseases 2013–2020. Geneva: World Health Organization; 2013.
12. Di Angelantonio E, Bhupathiraju SN, Wormser D, et al. Body-mass index and all-cause mortality: Individual-participant-data meta-analysis of 239 prospective studies in four continents. *The Lancet.* 2016;388:776–786.
13. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: A systematic review and meta-analysis. *JAMA.* 2013;309:71–82.
14. Lam TH. Absolute risk of tobacco deaths: One in two smokers will be killed by smoking: Comment on “Smoking and all-cause mortality in older people”. *Arch Intern Med.* 2012;172:845–846.
15. Romero-Corral A, Somers VK, Sierra-Johnson J, et al. Accuracy of body mass index in diagnosing obesity in the adult general population. *Int J Obes (Lond).* 2008;32:959–966.
16. Mathew H, Farr OM, Mantzoros CS. Metabolic health and weight: Understanding metabolically unhealthy normal weight or metabolically healthy obese patients. *Metabolism: Clinical and experimental.* 2016;65:73–80.
17. World Health Organization (WHO). BMI classification. 2006. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html, accessed 30 July 2016.
18. Visscher TL, Viet AL, Kroesbergen IH, Seidell JC. Underreporting of BMI in adults and its effect on obesity prevalence estimations in the period 1998 to 2001. *Obesity (Silver Spring).* 2006;14:2054–2063.
19. NCD Risk Factor Collaboration. Trends in adult body-mass index in 200 countries from 1975 to 2014: A pooled analysis of 1698 population-based measurement studies with 19.2 million participants. *The Lancet.* 2016;387:1377–1396.
20. World Health Organization (WHO). Global Health Observatory (GHO) data. 2015 Available from: http://www.who.int/gho/ncd/risk_factors/obesity_text/en/, accessed 2 August 2016.
21. House of Commons Health Committee. Obesity: Third report of session 2003–04. 2004. Available from: https://www.publications.parliament.uk/pa/cm200304/cmselect/cmhealth/23, accessed 18 October 2016.
22. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the

Global Burden of Disease Study 2010. *The Lancet.* 2013;380:2095–2128.

23. Kelly T, Yang W, Chen C-S, Reynolds K, He J. Global burden of obesity in 2005 and projections to 2030. *Int J Obesity.* 2008;32:1431–1437.
24. Finkelstein EA, Khavjou OA, Thompson H, et al. Obesity and severe obesity forecasts through 2030. *Am J Prevent Med.* 2012;42:563–570.
25. Office of Disease Prevention and Health Promotion. 2008 Physical activity guidelines for Americans. 2008. Available from: https://health.gov/paguidelines/guidelines/, accessed 8 February 2018.
26. The White House, Office of the First Lady. First Lady Michelle Obama launches Let's Move: America's move to raise a healthier generation of kids. 2010. Available from: https://obamawhitehouse.archives.gov/the-press-office/first-lady-michelle-obama-launches-lets-move-americas-move-raise-a-healthier-genera, accessed 8 February 2018.
27. Malik VS, Willett WC, Hu FB. Global obesity: Trends, risk factors and policy implications. *Nature Reviews Endocrinology.* 2013;9:13–27.
28. Swinburn B, Wood A. Progress on obesity prevention over 20 years in Australia and New Zealand. *Obesity Reviews.* 2013;14(Suppl. 2):60–68.
29. Go A, Mozaffarian D, Roger V. Sugar-sweetened beverages initiatives can help fight childhood obesity. *Circulation.* 2013;127:e6–e245.
30. Brownell KD, Farley T, Willett WC, et al. The public health and economic benefits of taxing sugar-sweetened beverages. *New England journal of medicine.* 2009;361:1599–1605.
31. The Lancet. Urgently needed: A framework convention for obesity control. [Editorial] *The Lancet.* 2011;378:741.
32. Lam TH. Obesity control: Learning from tobacco control and advocacy for a Framework Convention on Obesity Control (FCOC). *Proceedings of the 12th International Congress on Obesity*, 20 March 2014, Kuala Lumpur, Malaysia. 2014; 1-287..
33. Lam TH. Ethnic differences, obesity and cancer, stages of the obesity epidemic and cancer prevention. *Proceedings of te UICC World Cancer Congress*, 3–6 December 2014, Melbourne, Australia.
34. Food, Drug Administration, Department of Health and Human Services Food labeling; calorie labeling of articles of food in vending machines. Final rule. *Fed Regist.* 2014;79:71 259–71 293.
35. Lustig RH, Schmidt LA, Brindis CD. Public health: The toxic truth about sugar. *Nature.*

2012;482:27–29.

36. Malik VS, Popkin BM, Bray GA, Despres JP, Hu FB. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation.* 2010;121:1356–1364.
37. Hooper L, Martin N, Abdelhamid A, Davey Smith G. Reduction in saturated fat intake for cardiovascular disease. *Cochrane Database Syst Rev.* 2015; 6: CD011737.
38. Elder RW, Lawrence B, Ferguson A, et al. The effectiveness of tax policy interventions for reducing excessive alcohol consumption and related harms. *Am J Prevent Med.* 2010;38:217–229.
39. Jha P, Peto R. Global effects of smoking, of quitting, and of taxing tobacco. *New England Journal of Medicine.* 2014;370:60–68.
40. Lam TH, Jiang C, Chan YF, Chan SS. Smoking cessation intervention practices in Chinese physicians: Do gender and smoking status matter? *Health Soc Care Community.* 2011;19:126–137.
41. Rose SA, Poynter PS, Anderson JW, Noar SM, Conigliaro J. Physician weight loss advice and patient weight loss behavior change: A literature review and meta-analysis of survey data. *Int J Obesity.* 2013;37:118-28.
42. Potter MB, Vu JD, Croughan-Minihane M. Weight management: What patients want from their primary care physicians. *J Family Pract.* 2001;50:513–518.
43. Nawaz H, Katz DL. American College of Preventive Medicine practice policy statement: Weight management counseling of overweight adults. *Am J Prevent Med.* 2001;21:73–78.
44. Briscoe JS, Berry JA. Barriers to weight loss counseling. *The Journal for Nurse Practitioners.* 2009;5:161–167.

1. Karahalios A, English DR, Simpson JA. Change in body size and mortality: a systematic review and meta-analysis. *Int J Epidemiol* 2017; **46**: 526-46.
2. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. *Lancet* 2011; **378**: 804-14.
3. Doll R, Hill AB. The mortality of doctors in relation to their smoking habits. *British medical journal* 1954; **1**: 1451-55.

**Figure 1** Model of Obesity Epidemic: the criteria used to define the stages of the epidemic are based on level of obesity prevalence and obesity attributed mortality. Assuming 60 years between the current Stage 1 and Stage 2 to peak at a prevalence of 60%.