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Developing a framework for estimating the potential impact of obesity interventions in a European city

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For Peer Review

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Abstract

Obesity is global challenge for healthy populations. It has given rise to a wide range of public health interventions, focusing on supportive environments and lifestyle change, including diet, physical activity and behavioural change initiatives. Their impact is variable. However, more evidence is slowly becoming available and is **being** used to develop new interventions. However, in a period of austerity, a momentum is building to review these initiatives and understand what they do, how they do it and how they fit together. Our project seeks to develop a systematic framework for examining the complex web of initiatives at a policy, population, group and individual level aiming to promote healthy lifestyles, diet and physical activity levels or to reduce obesity through medical treatments. It produces a system for classifying different types of interventions into groupings which will enable them to be assessed and compared against the scientific evidence of clinical and/or cost effectiveness. Finally it seeks, where possible, to quantify the potential effects of different types of interventions on body mass index (BMI) and produce a cost per unit of BMI reduced.

Keywords: Obesity, intervention, framework, cost – effectiveness, public health, return on investment

Background

By the Second Millennium, global obesity had risen to epidemic levels (WHO, 2000). Ten years later, high body mass was ranked as the 6th largest risk factor in a *Global Burden of Disease Study 2010* produced by an international (GBD) team of the world's leading epidemiologists (Institute for Health Metrics, 2013). High body mass (as measured by Body Mass Index and typically used as an indicator of overweight) posted a 'dramatic' 82% increase in disability adjusted life years (DALYs) in the period 1990 to 2010. The United Kingdom (UK) component of the study, summarised in the *Lancet* and elaborated largely by a smaller GBD team of UK contributors (Murray et al, 2013), ranks high body mass as the 3rd largest risk factor.

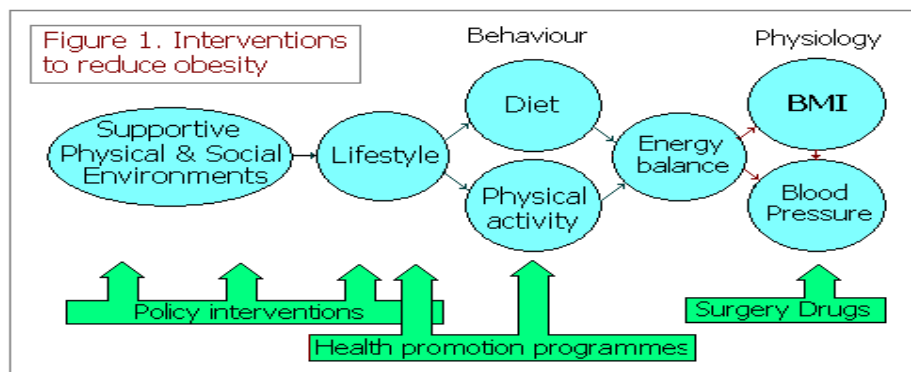
The study attributed impacts on cancer, cardiovascular and circulatory disease, diabetes and musculoskeletal disorders. Current trends in the UK indicate that, by 2015, 36% of males

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and 28% females will be obese and it is estimated that, by 2050, over half of the adult population could be obese (McPherson, Marsh & Brown, 2007).

So what can be done to reverse this health damaging trend? What are the most cost effective interventions? The UK GBD team raise three complicating issues. *First*, there are interactions within ~~their~~ clusters of risk factors. According to the WHO review of evidence (WHO, 2000) high BMI is correlated with high blood pressure and higher levels of cholesterol, both of which the GBD team identify as separate components of a physiological cluster. An intervention specifically designed to reduce BMI will probably also reduce these other risk factors. *Second*, there are interactions between clusters. The GBD team distinguish this physiological cluster from the behavioural cluster of dietary risk factors and physical inactivity, which in combination significantly determine BMI. *Third*, the GBD team acknowledge that though their focus is on these proximal and behavioural risks, wider social determinants have an important protective and promoting effect. This raises the critical question of how they are connected.

In our empirical study of four European cities (Whitfield et al, 2012), we adapted a model developed by De Leeuw (Leeuw (2009, 2012) which seeks to explicate the causal relationship between these proximal and distal determinants. Our focus was interventions by municipalities in six distal domains, which influence (1) living and working city environments, and then, sequentially (2) lifestyles, (3) behaviour and (4) five physiological risk factors for cardiovascular disease – Blood pressure, BMI, cholesterol, obesity and diabetes.



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3 However, though highlighting the salience of these distal influences, the WHO Collaborating
4 Centre for Obesity Prevention (Swinburn et al, 2011) developed ed s a framework which
5 acknowledges the reality of interventions at every stage in this dynamic sequence to combat
6 global drivers of obesity. We have synthesised this exposition with our causal sequence to
7 develop a conceptual or logic model of city obesity at city level encompassing both distal
8 and proximal interventions (figure 1). These may be policy interventions to influence
9 supportive physical and social environments (often in European cities, the responsibility of
10 municipalities) drugs and surgery administered by health services (often the responsibility of
11 central governments in European states) and health promotion programmes, often a shared
12 responsibility of municipalities, and the local operational arm of national health services
13 (Green, 1998 Kickbusch & Gleicher, 2012).
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24 Our focus in this article is the comparative cost-effectiveness of interventions at a city level
25 to reduce BMI. The seminal thesis of Thomas McKeowan (1979) on the limitations of
26 medicine and the primacy of wider, distal determinants of population health influenced the
27 equally influential work of the Global Commission on the Social Determinants of Health
28 (WHO Commission, 2008) and in the UK, the Marmot Review (Marmot et al, 2010). Their
29 policy recommendation is that distal interventions are more effective and sustainable in the
30 medium and longer term, a view echoed by Swinburn and associates. However, clinicians,
31 clinical epidemiologists and others have sought to rebalance the mix of interventions. As
32 Green & Tsouros (2007) and Lloyd (2012) argue, distal interventions maybe more effective
33 and sustainable in the longer term but in complex cities it is difficult to definitively trace
34 their outcomes in population behaviour and their impact on health. In contrast clinical
35 interventions usually have a proximate and quantifiable health impact.
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47 Based on a project in the United Kingdom, this article outlines an idea for a systematic
48 approach to examine the complex web of initiatives at policy, environmental, population,
49 group and individual levels aiming to promote healthy lifestyles, diet and physical activity
50 levels or to reduce obesity through medical treatments. It classifies different types of
51 interventions into groupings which will enable them to be assessed against the scientific
52 evidence of clinical and/or cost effectiveness. Finally it seeks where possible to quantify the
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potential effects of different types of interventions on body mass index (BMI) and produce a cost per unit of BMI reduced. The purpose of this article (and associated project) is to inform public health planners and decision takers of the extent of impacts of different types of interventions in shaping the lifestyle of populations and reducing obesity.

Methodology:

Before beginning our project, both the university research team and public health partners acknowledged that econometric modelling of the complex system summarised in figure 1 would not be possible with the resources available and within a realistic timescale. Some investment/outcome algorithms are relatively straightforward, for example estimating the impact on BMI of bariatric surgery. However, the three confounding issues identified by the UK GBD team apply to many other components of our city obesity model. There are complex causal pathways to BMI outcomes from distal investments to enhance supportive environments such as in green spaces and cycle ways. These only have impact if people use them. The impact will vary depending on who uses them and how they use them. Then there are complexities associated with payback time. For example, following lifestyle interventions to promote active childhood, when over the life course should be BMI outcome be measured? How long might the impact last? Third, there are interactions between interventions and confounders engrained within the social and environmental fabric of a city.

Therefore our modest ambition is to develop a 'Lean City Framework' of investments with a potential for reducing BMI in a city population. We adopted two key features of realist synthesis ([Pawson et al, 2005](#)).

First was a healthy two way dialogue with the policy community, from the initial expert framing of the problem to their final judgment on what works. Second we 'purposively sampled' then 'plugged in' evidence ([Boardman et al, 2011](#)) to construct a cost-benefit matrix. With the limited resources available, we mapped out the types or categories of interventions and the anticipated impacts as shown in the six stage process described below:

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5 **Stage 1** - As a first step the public health staff listed the key interventions currently running
6 in two local populations along with a brief description of the aims and objectives; the annual
7 cost of the intervention and the number of participants likely to be targeted impacted by
8 the intervention.
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11 **Stage 2** – Based on the logic model summarised in figure 1, we developed a classification
12 matrix to arrange the interventions into three groupings based on the type of intervention –
13 policy to enhance supportive environments, health promotion and surgery/drugs to change
14 physiology (Column 1 table 1) and the numbers of people targeted at a policy, population,
15 group or individual level. (Column 2 - 5, Table 1)
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17 **Stage 3** – We allocated interventions to each of the cells in the matrix (table 2). We
18 consulted local stakeholders to check if this allocation seemed sensible, and then made
19 adjustments according to feedback.
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21 **Stage 4** – We undertook a comprehensive search of the research literature for evidence of
22 impact of interventions on levels of obesity and undertook a purposive review to gauge the
23 strength of evidence of effectiveness and where possible estimates of the quantitative
24 impact of interventions on weight and BMI levels in the types of interventions classified in
25 each of the categories in the matrix (Table 1). Because of the limited resources available for
26 the project we were unable to carry out a systematic review of the evidence at this stage or
27 a meta-analysis of quantitative evidence of impact. Instead we used professional judgement
28 about the strength of the evidence and the likely levels of impact and underpinned each
29 assumption with a detailed explanation of how this was estimated.
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32 **Stage 5** - We overlaid the matrix of interventions with the matrix of evidence to relate
33 current investment to the evidence base of impact.
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35 **Stage 6** – Having collated information on the cost of the interventions, the number of
36 people impacted by them and the likely impact on mean BMI, we developed a simple
37 spreadsheet model which calculated the likely cost per unit of BMI reduced for a range of
38 interventions (Table 2, column 9).
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The purposive review included a formal search of scientific literature via electronic
databases MEDLINE and CINAHL. The search terms employed included obesity, overweight,

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3 BMI, parks, fast food, bicycle, green space, behaviour, primary care, lifestyle, counselling,
4 interventions, financial support, incentives, cities, towns, local council and district. A
5 combination of these terms and synonyms were used. All items within each section were
6 combined with OR and then each section was combined with AND for different
7 combinations of sections to produce the strongest result.
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13 The initial searches produced 2289 titles and abstracts including duplicates. After reading
14 titles and abstracts 1960 papers were excluded along with duplicates. The remaining 329
15 were classified into eight categories: cycle routes (n=9), lifestyle advice interventions (n=21),
16 parks (n=39), fast food (n=30), citywide campaigns (n=55), workplace (n=68), nutrition (n=56)
17 and planning documents (n=51). Based on titles and abstracts, each item was screened by
18 two researchers to determine its relevance to the matrix and accepted or rejected based on
19 the inclusion criteria. Approximately 250 articles were identified for inclusion in the matrix
20 and the full text retrieved. These articles were then inserted into the evidence matrix (table
21 1). Evidence from each cluster of papers was used to produce estimates of BMI reduction
22 (Column 7 table 2).
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Results:**Stage 1**

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35 Public health staff identified over 50 current interventions in an urban population in South
36 West England and 30 interventions in a nearby rural area. Of the 80 interventions identified,
37 managers in the various organisations leading the interventions were only able or willing to
38 give an estimate of the cost or budget for the intervention and the numbers of people likely
39 to use or become involved with it for 27 of the projects. None were able to give full baseline
40 demographic data about the targeted population nor a measure of baseline BMI.
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49 Only two had a target number of beneficiaries when the initiative was launched. There was
50 a growing reluctance to give information as the project developed. This appeared to be
51 based upon concern that funding might be withdrawn if an intervention did not perform
52 well. For this reason we agreed to present the framework with reference to anonymous
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populations and give generic titles to the example interventions shown for illustration purposes in table 2.

Stage 2

The 27 interventions were allocated cells within the 'Lean City matrix' (Table 2). Interventions aimed at infrastructure or environmental change such as cycle routes, workplace and school policies, planning restrictions or incentives etc. were classified under the heading supportive environments (n = 12). Interventions aimed at lifestyle, diet change or increasing physical activity were placed in the health promotion category (n = 13). Interventions related to direct health care interventions, mainly bariatric surgery related interventions were included in a surgery/drugs group (n = 2). The % change anticipated in BMI from the intervention was allocated from the literature review as shown in table 1 depending upon whether the initiative was primarily aimed at diet change, increased levels of physical activity or both.

Stage 3

The service managers classified the 27 interventions according to the estimated annual budget (column 3) estimated number of participants or beneficiaries (column 4) and the age group (column 5). Because of a lack of available baseline data, baseline BMI was simply based on national averages for the purpose of developing the framework at this stage.

Stage 4

In total, 37 papers were identified that reported BMI change and body weight loss. These are included in the list of references. Twelve reported body weight loss in lifestyle change at individual level category. A simple assessment was undertaken to determine the strength of evidence. Papers were checked for a clear research question, reasonable research design, and described either of the outcomes BMI or body weight change and contextual factors that contributed to the success or failure of intervention. Table 1 represents our summary of BMI and body weight change for each category. Based on strength of evidence, studies were classified as strong (indicated in green colour), mixed (indicated in yellow colour) and weak or absent.

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3 **Stage 5**

4 We focused on the objective outcome of an absolute change in BMI or body weight.
5 Evidence was extracted from the 37 studies to estimate the likely impact of the 27
6 interventions on BMI (Table 2, column 8).
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10 **Stage 6**

11 The results were then entered into a spreadsheet table to calculate the cost per unit of BMI
12 reduced for each type of intervention (Table 2, column 9). Given the relative unreliability of
13 the data on the cost of an intervention and the number of participants benefitting from it,
14 the lean City matrix at this stage was used as a tool to show the order of difference in return
15 on investment of different types of investment and the extent to which funded initiatives
16 correlated with areas underpinned by effectiveness evidence in the literature. The cost per
17 unit of BMI lost was derived from the following calculation:
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$$\text{Mean baseline BMI of participants} \times \text{the \% BMI reduction achieved in studies of}$$

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$$\text{similar interventions} = \text{the estimated average units of BMI lost per person.}$$

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31 This estimate was then multiplied by the number of participants to give the estimated
32 number of units of BMI reduction the programme might achieve. The total budget of the
33 programme was then divided by the number of units of BMI reduction to give a cost per unit
34 reduction.
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40 **Discussion**

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44 In this paper we have described a simple modelling matrix. Obesity is a major and growing
45 driver of cost pressures in health systems around the world. Billions of dollars are being
46 invested in combatting the problem at a policy level, population level, group level and
47 individual level. Some initiatives are aimed at increasing physical activity, some at improving
48 diet, others targeted at both through lifestyle change. Many are aimed at medical
49 interventions to reduce the problem once established and causing significant health
50 difficulties.
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Though there is evidence that distal interventions to reduce obesity may be more sustainable than proximal interventions targeted solely at changing lifestyle behaviour, there is a compelling case for investing at every level of the causal path illustrated by figure 1. There are lessons from the nineteenth and twentieth centuries. Significant advances in public health were achieved by addressing many of the environmental risk factors of "infectious" disease. Clean water, improved drainage and sewage disposal, better housing, better food, and improved living and working conditions together had a significant impact upon the problem. Yet, the subsequent development of vaccination and improved medical treatment also reduced and almost eradicated many common health problems of the era. Confining investment to distal, environmental determinants of clean water or better drainage and sewage control or working and living conditions would have limited the scope and slowed improvement of the public's health.

There is a parallel for the 21st Century. The aetiology behind the epidemic of non-infectious disease is complex, driven by many interacting determinants. Interventions are required at all levels. Yet there is evidence from the United Kingdom that these are uncoordinated. They often compete for resources. For example an initiative to engage "at risk" populations in one part of the population, competes for scarce resources with cardiac risk check programmes in another and a health trainer program in yet another part. Only common assessment and realignment will maximise their collective impact.

Table 2 in this paper is designed to help decision makers consider the range of initiatives already available in their area and the extent to which they link with current evidence of effectiveness. If the initiative is in a green square in table 1 the imperative to evaluate might be less than if it is in a red square. Collecting simple data on how much is currently being invested in different levels of initiative and how many people are potentially affected can provide a simple way to calculate the order of cost per unit of BMI reduced compared to alternative approaches. A more balanced portfolio of approaches might then be achieved.

The actual costs of reducing a unit of BMI shown in table 2 are provisional, based upon preliminary reports of the cost of initiatives and the numbers of people affected. The

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3 uncertainty is further exacerbated by provisional estimates of the baseline BMI of
4 participants. –Accuracy would be enhanced by substituting the generic assumptions on
5 impact on BMI derived from the scientific literature, with empirical data derived from
6 primary evaluations. The utility of the tool will increase significantly by making future
7 investment conditional on initiatives recording such data.
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12 13 14 **Conclusion**

15 Despite the limitations in populating our Lean City Matrix, this systematic attempt to classify
16 and compare different environmental and lifestyle change initiatives, equips local decision-
17 makers with the evidence to determine priorities, evaluate ‘best buy’ investments and
18 select future public health interventions.
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23 24 **Competing interests**

25 The authors declare that they have no competing interest.
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29 30 **References**

- 31 1. Boardman, A., Greenberg, D., Vining, A. and Weimer, D. (2011) *Cost-Benefit*
32 *Analysis: Concepts and Practice*. 4th ed. Upper Saddle River, NJ: Pearson Prentice
33 Hall.
34
- 35 2. Boardman, A., Greenberg, D., Vining, A. and Weimer, D. (1997) "Plug-in" shadow
36 price estimates for policy analysis. *The Annals of Regional Science* **31**(3), 299-324.
37
- 38 3. Bult, M. J. F., van Dalen, T. and Muller, A. F. (2008) Surgical treatment of obesity.
39 *Eur J Endocrinol*, **158**(2), 135-145.
40
- 41 4. Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J. and
42 Parry, V. (2007) *Tackling obesities: Future choices - Project report*. Government
43 Office for Science, 1-153.
44
- 45 5. Cobiac, L. J., Vos, T., and Barendregt, J. J. (2009) Cost-effectiveness of interventions
46 to promote physical activity: a modelling study. *PLoS medicine*, **6**(7).
47
- 48 6. Colgrove, J. (2002) The McKeown thesis: a historical controversy and its enduring
49 influence. *American Journal of Public Health*, **92**(5), 725-729.
50
- 51 7. Csizmadi, I., Siou, G., Friedenreich, C. M., Owen, N. and Robson, P. J. (2011) Hours
52 spent and energy expended in physical activity domains: results from the Tomorrow
53 Project cohort in Alberta, Canada. *The international journal of behavioural nutrition*
54 *and physical activity*, **8**(1), 110-110.
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Obesity (v14) June 6

8. Dalziel, K., Segal, L. and Elley, C. R. (2006) Cost utility analysis of physical activity counselling in general practice. *Aust N Z J Public Health*, **30**(1), 57-63.
9. De Leeuw, E. (2009) Evidence for Healthy Cities: reflections on practice, method and theory. *Health Promotion International*, 24(suppl 1).
10. De Leeuw, E. (2012) Do healthy cities work? A logic of method for assessing impact and outcome of healthy cities. *Journal of urban health: bulletin of the New York Academy of Medicine*, **89**(2), 217-231.
11. Devi, A., Surender, R. and Rayner, M. (2010) Improving the food environment in UK schools: Policy opportunities and challenges. *J Public Health Policy*, **31**(2), 212-226.
12. Freudenberg, N., Libman, K. and O'Keefe, E. (2010) A tale of two obesCities: the role of municipal governance in reducing childhood obesity in New York City and London. *Journal of urban health*, **87**(5), 755-770.
13. Geshnizjani, A., Sheats, J. L., Arvin, C. S., Sullivan, M. R. and Middlestadt, S. E. (2011) Factors Associated With Participation in Work-Site Wellness Programs: Implications for Increasing Willingness Among Rural Service Employees. *Health Education & Behaviour*, **38**(5), 502-509.
14. Green, G. (1998) Health and Governance in European Cities: a Compendium of Trends and Responsibilities for Public Health in 46 Member States of the European Region. Copenhagen. WHO Regional Office for Europe.
15. Green, G. and Tsouros, A. (2007) Evaluating the impact of healthy cities in Europe. *Italian Journal of Public Health*, **4**, 255-260
16. Henderson, A. and Fry, C. R. (2011) Better parks through law and policy: a legal analysis of authorities governing public parks and open spaces. *Journal of physical activity & health*, **8**(Suppl 1), 109-115
17. Huang, N., Pietsch, J., Naccarella, L. and Sims, J. (2004) The Victorian Active Script Programme: promising signs for general practitioners, population health, and the promotion of physical activity. *Br J Sports Med*, **38**(1), 19-25.
18. Institute for Health Metrics and Evaluation. (2013) The Global Burden of Disease: Generating Evidence, Guiding Policy. Seattle. IHME.
<http://allafrica.com/download/resource/main/main/idatcs/00060478:d5f517b09653cf7b5bed47287bed1dae.pdf>
19. Joosse, L., Stearns, M., Anderson, H., Hartlaub, P. and Euclide, J. (2008) Fit Kids/Fit Families: a report on a countywide effort to promote healthy behaviours. *WMJ*, **107**(5), 231-236.
20. Kamada, M., Kitayuguchi, J., Inoue, S., Kamioka, H., Mutoh, Y. and Shiwaku, K. (2009) Environmental correlates of physical activity in driving and non-driving rural Japanese women. *Prev Med*, **49**(6), 490-496.
21. Kickbusch, I. and Gleicher, D. (2012) Governance for Health in the 21st Century. Geneva. World Health Organization.

Obesity (v14) June 6

22. Kopelman, P. (2007) Health risks associated with overweight and obesity. *Obesity Reviews*, **8**(Suppl 1), 13-17.
23. Kruger, J., Lankford, T. and Schmid, T. (2010) State Legislative Support for Parks. *Environmental Health Insights*, **4**, 27-31.
24. Link, B. G. and Phelan, J. C. (2002) McKeown and the idea that social conditions are fundamental causes of disease. *American Journal of Public Health*, **92**(5), 730-732.
25. Lloyd, L. (2012) *Health and Care in an Ageing Society: A New International Approach*. Bristol. Policy Press.
26. Maggard, M. A., Shugarman, L. R., Suttorp, M., Maglione, M., Sugerman, H. J., Livingston, E. H., Nguyen, N. T., Li, Z., Mojica, W. A., Hilton, L., Rhodes, S., Morton, S. C. and Shekelle, P. G. (2005) Meta-analysis: surgical treatment of obesity. *Ann Intern Med*, **142**(7), 547-559.
27. Marmot, M. G., et al. (2010) Fair society, healthy lives: strategic review of health inequalities in England post-2010. University College London.
28. McDoniel, S. O., Wolskee, P. and Shen, J. (2010) Treating obesity with a novel hand-held device, computer software program, and Internet technology in primary care: The SMART motivational trial. *Patient Educ Couns*, **79**(2), 185-191.
29. McKeowan, T. (1979) *The role of medicine; dream, mirage or nemesis*. Oxford. Blackwell.
30. McKeown, T (1965) *Medicine in Modern Society*. London, England: Allen & Unwin.
31. McMahan, S., Hampl, J. and Chikamoto, Y. (2003) A "fat" tax: Knowledge and attitudes of snack food taxing among college students. *American Journal of Health Education*, **34**(6), 329.
32. Mcpherson K, Marsh T, and Brown, M. (2007) Tackling Obesities - Future Choices - Modelling Future Trends in Obesity and the Impact on Health. Government Office for Science, 1-70. (<http://www.foresight.gov.uk>).
33. Mitchell, N. S., Dickinson, L. M., Kempe, A. and Tsai, A. G. (2011) Determining the effectiveness of Take Off Pounds Sensibly (TOPS), a nationally available nonprofit weight loss program. *Obesity (Silver Spring)*, **19**(3), 568-573.
34. Murray, C., et al. (2013) UK health performance: findings of the Global Burden of Disease Study 2010. *Lancet*, **381**, 997-1020.
35. Pawson R., Greenhalgh, T., Harvey, G. and Walshe, K. (2004): *Realist synthesis: an introduction*. ESRC Research Methods Programme.
36. Pawson, R., Greenhalgh, T., Harvey, G. and Walshe, K. (2005) Realist review- a new method of systematic review designed for complex policy interventions. *J Health Serv Res Policy*, **10**(Suppl 1), 21-34.
37. Pawson, R. and Tilley, N. (1997) *Realist Evaluation*. London. Sage.

Obesity (v14) June 6

38. Peterson, J. A. (2007) Get moving! Physical activity counselling in primary care. *J m Acad Nurse Pract*, **19**(7), 349-357.
39. Powell, L. M., Chriqui, J. and Chaloupka, F. J. (2009) Associations between State-level Soda Taxes and Adolescent Body Mass Index. *Journal of Adolescent Health*, **45**(3), 57-63.
40. Powell, L. M., Han, E. and Chaloupka, F. J. (2010) Economic contextual factors, food consumption, and obesity among U.S. adolescents. *J Nutr*, **140**(6), 1175-1180.
41. Probart, C. (2008) Statewide assessment of local wellness policies in Pennsylvania public school districts. *J Am Diet Assoc*, **108**(9), 1497.
42. Pritchard, J., Nowson, C., Billington, T. and Wark, J. (2002) Benefits of a year-long workplace weight loss program on cardiovascular risk factors. *Nutrition & Dietetics*, **59**(2), 87-96.
43. Sevick, M. A., Dunn, A. L., Morrow, M. S., Marcus, B. H., Chen, G. J. and Blair, S. N. (2000) Cost-effectiveness of lifestyle and structured exercise interventions in sedentary adults: Results of project ACTIVE. *Am J Prev Med*, **19**(1), 1-8.
44. Sevick, M. A., Napolitano, M. A., Papandonatos, G. D., Gordon, A. J., Reiser, L. M. and Marcus, B. H. (2007) Cost-effectiveness of alternative approaches for motivating activity in sedentary adults: results of Project STRIDE. *Prev Med*, **45**(1), 54-61.
45. Swinburn, B., et al. (2011) The global obesity pandemic: shaped by global drivers and local environments. *Lancet*, **378**, 804-814.
46. Szreter, S. (2002) Rethinking McKeown: The Relationship Between Public Health and Social Change. *American Journal of Public Health*, **92**(5), 722-725.
47. Wang, G., Macera, C. A., Scudder-Soucie, B., Schmid, T., Pratt, M. and Buchner, D. (2004) Cost effectiveness of a bicycle/pedestrian trail development in health promotion. *Prev Med*, **38**(2), 237-242.
48. Whitfield, M., Machaczek, K. and Green, G. (2012). Developing a model to estimate the potential impact of municipal investment on city health. *Journal of Urban Health*.
49. World Health Organisation. (2000) Obesity: Preventing and managing the global epidemic - Introduction. Geneva. WHO technical report series 894, 1-16. http://whqlibdoc.who.int/trs/WHO_TRS_894.pdf
50. WHO Commission on Social Determinants of Health. (2008) Closing the gap in a generation. Health equity through action on the social determinants of health. Geneva. World Health Organization.
51. Wanless, D. (2004) *Securing good health for the whole population: final report*. London: HMSO.
52. Watson-Jarvis, K., Johnston, C. and Clark, C. (2011) Evaluation of a family education program for overweight children and adolescents. *Canadian journal of dietetic practice and research*, **72**(4), 191-196.

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53. Waters, E., Armstrong, R., Swinburn, B., Moore, L., Dobbins, M., Anderson, L., Petticrew, M., Clark, R., Conning, R., Moodie, M. and Carter, R. (2011) An exploratory cluster randomised controlled trial of knowledge translation strategies to support evidence-informed decision-making in local governments (The KT4LG study). *BMC Public Health*, **11**(1), 34-34.

Figures

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Table 1 Analysis of literature on BMI change and body weight loss

Column 1	Column 2		Column 3		Column 4		Column 5	
	Policy Level		Population Level		Group Level		Individual Level	
	BMI Change	Weight Loss	BMI Change	Weight Loss	BMI Change	Weight Loss	BMI Change	Weight Loss
Health promotion			This category contains one study reported 3.4% reduction in BMI.	This category contains one study reported 1.5% decrease in body weight.	This category contains five studies reported BMI reduction ranges from 1 to 2% (average = 1.4%)	This category contains four studies reported body weight loss ranges from 1.5 to 5% (average= 3%)	This category contains eight studies reported BMI reduction ranges from 1 to 8% (average = 3%)	This category contains 12 studies reported body weight loss ranges from 0.25 to 6.7% (average = 3.3%)
	This category contains one study reported 0.5% reduction in BMI.	This category contains one study reported 1.5% decrease in body weight.	This category contains one study reported 1% reduction in BMI.	This category contains one study reported 0.5% decrease in body weight.	This category contains two studies reported 1 & 3% (average=2%) reduction in BMI.	This category contains three studies reporting body weight loss ranges from 0.5 to 3% (average = 1.6%)	This category contains five studies reporting BMI reduction ranges from 1 to 10% (average = 4%)	This category contains three studies reporting body weight loss ranges from 1 to 3.9% (average = 3.6%)
Supportive environment			This category contains two studies reported 1 & 3.4% (average=2.2%) reduction in BMI.	This category contains one study reported 0.5% decrease in body weight.	This category contains two studies; each reported 1% reduction in BMI.	This category contains three studies reported body weight loss ranges from 0.5 to 4% (average = 2.8%)	This category contains four studies reported BMI reduction ranges from 1 to 3% (average= 1.7%)	This category contains three studies reporting body weight loss ranges from 1 to 3.3% (average = 2.7%)
Surgery/drugs							This category contained two studies reported 35 and 39% reduction in excessive body mass index (BMI).	This category contains six studies reported decrease in excessive body weight, it ranges from 25 to 70% (average = 44.6%).

For the three intervention categories of intervention, green cells represent strong evidence available, yellow cells represent mixed evidence, red cells represent weak or no evidence.

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Table 2.

Lean City Framework: cost per unit of BMI reduced for each category of intervention

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Intervention	Type	Budget	Participant	Age group	Mean BMI	Impact on BMI	Mean BMI Reduction	Cost / BMI Unit
School initiative nutrition and health	Supportive Environment	£45,000	400	Children	20	3.40%	272	£9.31
Workplace health initiative	Supportive Environment	£8,500	120	Adults	27.5	3.40%	112.2	£75.76
Convenience stores initiative	Supportive Environment	£14,000	900	Adults	27.5	1.00%	247.5	£56.57
Healthier catering initiative	Supportive Environment	£4,000	100	Adults	27.5	1.00%	27.5	£145.45
Nutrition in care homes initiative	Supportive Environment	£9,450	340	Adults	27.5	1.00%	93.5	£101.07
City wide increased physical activity	Supportive Environment	£5,000,000	330000	Adults	27.5	3.40%	3E+05	£16.20
Increased cycle routes	Supportive Environment	£350,000	4500	Adults	27.5	3.40%	4208	£83.18
Increased use of parks	Supportive Environment	£58,000	1250	Adults	27.5	3.40%	1169	£49.63
Children's healthy weight initiative	Supportive Environment	£25,000	450	Children	20	2.20%	198	£126.26
Obesity prevention for 3-4 year olds	Health Promotion	£87,000	4017	Children	20	2.00%	1607	£54.14
Healthy eating initiative	Health Promotion	£3,000	220	Adult	27.5	2.00%	121	£24.79
After school health promotion	Health Promotion	£5,000	900	C&YP	23	2.20%	455.4	£10.98
Sports initiative children	Health Promotion	£35,000	452	Young adults	23	1.40%	145.5	£240.48
Walking for Health	Health Promotion	£60,000	1300	Adult	27.5	1.40%	500.5	£119.88
Adult weight management	Health Promotion	£369,000	1680	Adults	30	3.00%	1512	£244.05
Maternal obesity pathway	Health Promotion	£53,246	450	Adults	30	3.00%	405	£131.47
Lifestyle choice program	Health Promotion	£53,200	172	Adults	27.5	3.00%	141.9	£374.94
Online weight management	Health Promotion	£6,000	1400	Adults	27.5	3.00%	1155	£5.19
Primary care brief interventions	Surgery / drugs	£32,000	250	Adults	27.5	3.00%	206.3	£155.15
Monthly weight clinic wheel chair users	Health Promotion	£15,120	114	Adult	27.5	3.00%	94.05	£160.77
Bariatric surgery	Surgery / drugs	£1,350,000	150	Adults	45	39%	2633	£512.82
Healthy fast food initiative	Supportive Environment	£27,500	1300	Adults	27.5	0.50%	178.8	£153.85
Coaching project	Supportive Environment	£21,000	200	Adult	27.5	0.50%	27.5	£763.64
Fast food planning initiative	Supportive Environment	£5,500	1300	Adults	27.5	0.50%	178.8	£30.77
Citywide obesity campaign	Health Promotion	£33,000	2500	Adults	27.5	0.50%	343.8	£96.00
Telephone intervention	Health Promotion	£22,500	45	Children	20	3.00%	27	£833.33
Sport promotion	Health Promotion	£8,000	90	Adult	27.5	3.00%	74.25	£107.74

Reviewer's comments and responses

No	Reviewer 1 comments	Response
	Abstract	
1	Need more balance in the abstract? Most of the abstract is on background and aims. Says little about actual methods and nothing on results or significance.	Revised.
	Background	
2	Para 3, line 2 refers to 'their clusters of risk factors' – who or what does the 'their' refer to? May be the 'their' should be removed.	Done
3	Para 4, last line – should include all the 5 physiological risk factors in Figure 1.	The given figure is adopted from Leeuw, 2009's work.
4	Para 5, line 3 –term 'city obesity' warrants explanation.	Done
	Methodology	
5	The authors rightly acknowledge that the economic modelling associated with determining the health benefits of obesity interventions is complex. However, there are several groups around the world who have done this exercise in a more rigorous and comprehensive manner.	Agreed as we have acknowledged that economic modelling could be done with sufficient resources and realistic timescale as these were major limitations of this project. This matrix allows municipalities or local authorities to classify their current portfolio of interventions into different areas quickly and cheaply. They can then require providers to provide basic information of the cost of the interventions and the number of beneficiaries and get a feel for the balance of the portfolio and the potential performance of project delivery.
6	Stage 1 – is confined to interventions currently running in two communities. There is no provision for inclusion of other interventions not currently being provided to be included.	The project provided a framework for current interventions to be placed into a matrix. Other users can insert their own portfolio of provision using the same tool. The broad impact of different interventions can then be applied to similar types of interventions until such time as actual data becomes available.
7	Stage 1 – the annual cost of the intervention is not defined, but probably refers to the financial cost (costs as in a finance balance sheet). To do this exercise properly, economic costs need to be used rather than financial costs (costs of all resources regardless of whether they are traded in the marketplace).	Agreed. As stated earlier the idea is to provide a simple cheap method for funders to carry out such an assessment to identify the mix of their portfolios and the estimated impact on BMI. The cost is simply the cost to the funder at this stage. Most funders cannot afford to carry out sophisticated studies of total cost for such investment decisions.
8	Stage 2 – refers to numbers of people targeted by an intervention, which may be quite different to the numbers likely to be impacted (as mentioned in Stage 1). In the	This is adjusted.

	Results, Stage 1, the authors refer to the number of people likely to use or become involved with, and in Stage 3 results, says number of beneficiaries. Definition needs to be consistent throughout – need to know who will receive the benefit, and how will that be defined.	
9	Stage 4 – how was strength of evidence measured and classified?	A simple assessment was undertaken to determine the strength of evidence. Papers were checked for a clear research question, reasonable research design, and described either of the outcomes BMI or body weight change and contextual factors that contributed to the success or failure of intervention. Based on strength of evidence, studies were classified as strong (indicated in green colour), mixed (indicated in yellow colour) and weak or absent.
10	Stage 6 – this methodology seems very crude. For example, no account has been taken of the context, specific setting, or delivery model of interventions to determine how the effect size (drawn from the literature) may be affected in reality.	This is fair comment. At present these investments are made, often independently of each other and often with no clear expectation of impact. The framework is a first step in bringing together the decision making process to allow a more systematic and comprehensive view of the problem. The areas involved had significant difficulty identifying the services they provided let alone what they cost and how they performed. If a funder got to the stage where they had an understanding of the current investment and the levels of activity this would be an obvious next iteration of the methodology
11	Literature search - the 8 categories used to classify the identified papers do not seem to cover all of the parameters mentioned in Figure 1.	Due to limited resources available for the project we were unable to carry out a systematic review of the evidence at this stage or a meta-analysis of quantitative evidence of impact. Instead we used 'berry picking search approach' to cover all parameters.
12	Last line of methods – it is very crude to combine evidence from each cluster of papers to produce estimates of BMI reduction. Effect sizes will vary dramatically depending on the type and specific characteristics of individual workplace interventions, or nutrition interventions.	Agreed. The intention was to give an indicative assessment of likely impact that could be used as a default assumption until such time that more accurate data from reviews or evaluations of actual projects.
	Results	
13	Stage 4 – not clear how the 37 papers relate to the 329 papers initially identified.	The initial searches produced 2289 titles and abstracts including duplicates. After reading titles and abstracts 1960 papers were excluded along with duplicates. The remaining

		329 were classified into eight categories: cycle routes (n=9), lifestyle advice interventions (n=21), parks (n=39), fast food (n=30), citywide campaigns (n=55), workplace (n=68), nutrition (n=56) and planning documents (n=51).
14	Stage 4 – simple strength of evidence assessment – what is a ‘reasonable research design’? Nothing about sample size etc .	Reasonable research design means appropriate and adequate to answer the research question that also covers sample size, methods and results.
15	The authors themselves acknowledge the crudity of both the intervention costing and the estimates of benefitting participants. Given that the BMI estimates are also very crude, it is highly unlikely that the matrix can reliably rank the intervention types in terms of return on investment.	The intention is not to rank the return on investment at this stage but rather to indicate the likely impact on BMI of different categories of intervention. The impact on relative return on investment will be a product of the estimated reduction in BMI, the cost of the specific intervention locally and the number of people engaged in the service. Engaging more people or reducing cost will positively affect the estimated return on investment. Again the broad estimates in the framework can be replaced by actual data over time
16	I don't think any respected obesity experts have argued for confining interventions to one category or one part of the spectrum (shown in Fig 1). Generally the arguments have been that obesity needs to be tackled at many levels, across all sectors of society (health and non-health), at both proximate and distal levels, and at both a population level and an individual level (across all target groups).	Agreed. The framework does not argue for restricting interventions to single categories. On the contrary it encourages the identification of gaps in the portfolio across a population.
17	Last paragraph –research such as the ACE (Assessing Cost-Effectiveness) studies in Australia have done such priority setting exercises in a rigorous way and incorporated extensive probabilistic uncertainty analysis.	Agreed.
18	The conclusion is very thin, and is highly questionable as to whether the tool produced does equip decision-makers to do effective priority setting.	The tool equips decision makers to make more informed decisions than at the current time. The replacement of estimated impact and assumptions with real data will allow incremental improvement over time.
	Table 2	
19	Are all the monetary values been inputted for the same reference year – otherwise they are not comparable.	Yes. The cost data is based upon current budgets.
20	Column 8 – what are the units? They don't make sense as mean BMI reductions.	True - They are the estimated aggregated BMI loss for the people using the service.

21	None of the interventions listed seem to fit the category of distal interventions as used by authors such as Swinburn.	Initiatives such as planning initiatives restricting fast food outlets, sport promotion and facilitation of the use of parks and cycle ways are examples of policy level and population level initiatives that provide a conducive environment for healthier lifestyles rather than direct interventions aimed at individuals.
	Minor Changes	
	Abstract	
1	Line 17 -- insert word '...is being used'	Done
2	Line 17 – remove word 'a' before 'momentum'	Done
	Background	
3	Para 4, line 1 – insert comma after 2012),	Done
4	Para 5 – tenses need attention. Line 2 – should be 'developed a framework'	Done
5	Para 5, line 5 – insert comma after responsibility of municipalities),	Done
	Methodology	
6	Stage 4, line 4 – make 'resource' plural	Done
	Reviewer 2 comments	
1	The paper is very interesting, well developed and easily understood. It may serve as a helpful tool for planners and decision makers in prioritising health promotion activities in local communities. It is suggested that the authors in their discussion discuss the problem in using average and aggregate outcome measures (change in mean BMI for the whole target population). The calculation will tempt the reader to believe that the interventions reaches all in the target group, or are being accepted by all, or do have an impact on all. And will tend to conceal that some will even be damaged by the intervention (social stigma when being classified as obese, incurring of extra costs among low income citizens if tobacco prices are increased etc). Parallel to the calculation of average impacts, measures needed to be developed and implemented for health promotion similar to NNT (Numbers needed to treat) or NNH (numbers needed to harm) or new	Thanks for valuable comments. We have tried to respond to all your comments in the main text.

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	<p>and innovative measures like "numbers needed to invite", "numbers needed to stimatize" "numbers needed to charge excess tobacco prizes") - or similar to that, so the Cost-benefit/effectiveness considerations/calculations become more realistic. And takes into account both that not all in the target group will benefit from the intervention, and that even some will have negative impacts.</p>	

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