



# Environmental determinants of overweight and obesity: Extended international literature review

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Final report

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Commissioned by the Federal Office of Public Health (FOPH)

Winterthur, June 2009

## **Publisher's Imprint**

Contract number:	07.005756
Contract period:	November 2007 – Decembre 2009
Period covered by literature review	Jan 1980 – May 2008
Reviewed by:	A critical review of the report was conducted by the FOPH, Evaluation and Research (E+R), in collaboration with members of the Study's Scientific Advisory Group
Available from:	Evaluation and Research Centre (E+R), Federal Office of Public Health, CH-3003 Bern evaluation@bag.admin.ch www.health-evaluation.admin.ch
Recommended citation:	Schmidhauser, Sara, Simon Wieser, and Urs Brügger: Environmental determinants of overweight and obesity: Extended international literature review. Final report. Study commissioned by the Federal Office of Public Health. Winterthur: 2009.

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## Abstract

A systematic literature search was performed to identify the determinants in the environment that have contributed to obesity and overweight in OECD countries and that can explain time trends and cross-sectional differences. We found 677 studies that fulfilled the criteria, of which 318 related to some measure of socioeconomic status (education, income, occupation) only. The studies were grouped with the help of a two-dimensional thematic map consisting of six environmental domains (politics & law, economics, society & culture, technology, the physical & natural environment and policy measures) and three levels (micro, meso and macro).

The obesity epidemic can plausibly be traced back to a multitude of environmental factors that are most often essentially the result of long-run improvements to enhance individual or social welfare. Thus, the obesity epidemic is part and parcel of some developments which cannot or should not be reversed.

Eine systematische Literatursuche wurde durchgeführt, um die umweltbedingten Bestimmungsfaktoren von Übergewicht und Adipositas in OECD-Ländern zu bestimmen, welche Entwicklungen über die Zeit und Unterschiede zwischen verschiedenen Bevölkerungsschichten erklären können. Es wurden 677 Studien gefunden, welche die Kriterien erfüllten, wovon alleine 318 den sozioökonomischen Status betrafen (Bildung, Einkommen, Beruf). Die Studien wurden mit Hilfe einer zweidimensionalen thematischen Landkarte bestehend aus sechs Feldern (1) Politik, (2) Ökonomie, (3) Gesellschaft und Kultur, (4) Technologie, (5) physische natürliche Umwelt und (6) Politikinterventionen und drei Ebenen (Mikro, Meso, Makro) gruppiert.

Die Übergewichts-Epidemie kann auf eine Vielfalt von Umweltfaktoren zurückgeführt werden, welche in vielen Fällen das Resultat von langfristigen Veränderungen sind, die auch zur Verbesserung der individuellen und sozialen Wohlfahrt beigetragen haben. Folglich ist die Übergewichts-Epidemie auch Teil von Entwicklungen, die nicht rückgängig gemacht werden können und sollen.

Une revue de littérature systématique a été réalisée afin d'identifier les déterminants environnementaux qui ont contribué à l'augmentation de l'obésité et du surpoids dans les pays de l'OCDE et qui peuvent expliquer l'évolution dans le temps et les différences entre les classes sociales. La recherche documentaire a mis à jour 677 études qui remplissent les critères, parmi lesquelles 318 portant sur le statut économique (formation, revenu, emploi) uniquement. Les études ont été groupées au moyen d'une carte thématique bi-dimensionnelle composée de six domaines : politique et législation, économie, société et culture, technologie, environnement physique et naturel, mesures politiques, et de trois niveaux : micro, meso et macro.

L'épidémie d'obésité peut être imputée à des facteurs environnementaux qui sont essentiellement le résultat d'améliorations sur le long terme qui accroissent aussi le bien-être individuel et social. L'épidémie d'obésité est ainsi partie intégrante de développements qui ne peuvent pas ou ne devraient pas être réversibles.

**Key words**

Obesity, overweight, body mass index, BMI, systematic literature search, environmental factors, economic determinants

Adipositas, Übergewicht, Body-Mass-Index, BMI, systematische Literatursuche, Umweltfaktoren, ökonomische Bestimmungsfaktoren

obésité, surpoids, indice de masse corporelle, IMC, revue de littérature systématique, facteurs environnementaux, déterminants économiques

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## **Acknowledgements**

This study has been commissioned by the section 'Evaluation and Research' of the Swiss Federal Office of Public Health (SFOPH). We wish to acknowledge in particular the considerable support and guidance received during the preparation of the report from Marlène Läubli Loud, head of the section 'Evaluation and Research'.

We have received special advice and recommendations throughout the research project from the project's scientific advisory group: Günter Ackermann (Health Promotion Switzerland), Brigitte Buhmann (Swiss Council for Accident Prevention bfu), Michele Cecchini (OECD), Gianfranco Domenighetti (Università della Svizzera Italiana), David B. Evans (WHO), Ilona Kickbusch (PH Consultant), Jean Simos (Université de Genève), France Weaver (Obsan). Their comments and their scientific support were very helpful and are particularly acknowledged.

The authors are further indebted to Dr. med. Philipp Stalder of the Medical Library Careum at the University of Zurich for his valuable contribution to the literature search in the electronic medical databases.

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## The mandate

In the light of the growing obesity epidemic Switzerland is currently developing a strategy for encouraging healthy lifestyles and a healthy balance of nutrition and exercise. As part of its planning, the Swiss Federal Office of Public Health (SFOPH) called upon the WIG to provide it with research evidence in this domain. Relevant knowledge can be provided from two sources: (1) in order to evaluate the Federal Office's strategy and interventions one needs to know what research exists worldwide on key environmental factors which lead to obesity and overweight in order to decide what data is needed for future strategic evaluation in Switzerland, but also (2) to know the data availability in Switzerland in order to use existing data appropriately. Together, these two parts are intended to help the SFOPH's intervention policy and evaluation strategy of obesity and overweight.

This study is intended to fulfil part one of these needs – namely to study what key environmental factors should be taken into account. The method chosen is a literature review. Most of the literature found is from North America. Therefore the question is to what extent the results can be transferred to the European and particularly the Swiss context. The obesity epidemic has started earlier in the United States than in Europe. Recent trends have shown that other OECD countries follow the development in the US with a time lag. There is good reason to believe that at least some of the underlying trends are not only a local but a universal phenomenon. However, there are certainly cultural and other differences that are important and that need to be considered when a Swiss strategy is developed. The question is whether the development of overweight and obesity can be stopped before the prevalence rates reach US levels. The Swiss strategy intends to do just that and the study at hand wants to contribute to this goal with a piece of the necessary knowledge.



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## Summary

**Context:** Overweight and obesity prevalence have been rising sharply in high income countries in the past 25 years. Some groups in the population exhibit higher prevalence rates of overweight and obesity than others.

**Objectives:** To identify the determinants in the environment that have contributed to obesity and overweight in OECD countries and that can explain time trends and cross-sectional differences.

**Method:** Systematic literature search

**Data Sources:** electronic medical databases (Medline, Embase, Cochrane Library, PsycINFO, and Psycdex Plus); electronic economics and social sciences databases (Social Science Research Network SSRN, National Bureau of Economic Research NBER Working Papers database, ECONIS, wiso Wirtschafts- und Sozialwissenschaften, EconPapers, and IDEAS RePec); bibliographies of retrieved articles; hand-searching in the internet.

**Study Selection:** Studies were eligible for inclusion if they reported on influences 'outside the individual' on overweight or obesity, were done in an OECD country, and had either an experimental design or an observational design (cohort study, case-control study, cross-sectional study).

**Results:** We found 677 studies that fulfilled the criteria, of which 318 related to some measure of socioeconomic status (education, income, occupation) only. We grouped the studies with help of a two-dimensional thematic map consisting of six environmental domains (politics & law, economics, society & culture, technology, the physical & natural environment and policy) and three levels (micro, meso and macro). Overall, research has been active in all domains of the environment but not always on all levels. We also found a steep increase in the number of studies published in the recent approximately 5 years.

An in-depth analysis of the 14 studies on the effects of macro-level policy activities on body weight status showed that these studies relate to a variety of policy measures such as physical education in schools, smoking, education, environment regulation and food market regulations (taxes, subsidies, etc.). The results highlight that policy measures even from fields such as agriculture, education, and market regulations may have an impact on obesity rates.

A myriad of environmental factors can theoretically determine individuals' decisions and give rise to a positive energy balance (energy intake > energy outflow). Environmental factors of five domains clearly contributed to an increase in energy intake and a decrease in energy consumption overall. The results from the policy domain are mixed and somewhat unclear.

**Conclusions:** The obesity epidemic can plausibly be traced back to a multitude of environmental factors that are most often essentially the result of long-run improvements to enhance individual or social welfare. Thus, the obesity epidemic is part and parcel of some developments which cannot or should not be reversed.

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**Recommendations:** The in-depth analysis on the macro-level policy measures' impact provides an indication that policy measures can have an impact on obesity. Therefore, it may make sense to re-evaluate existing policies to assess whether they might bring forth unintended consequences or provide incentives that should be enhanced. Accordingly, for future activities, an integrated approach seems worthwhile to ensure collaborations with agencies that have parallel goals and coordinate with those who have conflicting goals.

For future policy activities we recommend to first assess the need for action in Switzerland according to the exposure of individuals to the hazards as identified in this review. In a second step, the possibilities for action and the potential changeability of determinants need to be evaluated. As a third step, we recommend that future research be primarily specific to the relevance of the aspects to the Swiss environment and that it be solution-oriented. An important avenue for future research may be to focus on the limitations of the rational choice model in the case of obesity and ways to deal with it.

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## List of abbreviations

<i>BMI</i>	<i>Body mass index</i>
<i>CBA</i>	<i>Cost-Benefit Analysis</i>
<i>GDP</i>	<i>Gross domestic product</i>
<i>PE</i>	<i>Physical education</i>
<i>WIG</i>	<i>Winterthur Institute of Health Economics (Winterthurer Institut für Gesundheitsökonomie)</i>
<i>ZHAW</i>	<i>Zurich University of Applied Sciences (Zürcher Hochschule für Angewandte Wissenschaften)</i>

## Glossary

<i>Bias (systematic error)</i>	<i>A tendency to produce results that depart systematically from the 'true' results. Unbiased results are internally valid. (NHS Centre for Review and Dissemination 2001)</i>
<i>Case-control study</i>	<i>Comparison of exposure to interventions between participants with the outcome (cases) and those without the outcome (controls). (NHS Centre for Review and Dissemination 2001)</i>
<i>Cohort study</i>	<i>Comparison of outcomes between participants who have received an intervention and a group that has not (i.e. not allocated by investigator) in a follow-up study. (NHS Centre for Review and Dissemination 2001)</i>
<i>Confidence interval</i>	<i>Confidence interval is the imprecision in the point estimate, i.e. the range around it within which the 'true' value of the effect can be expected to lie with a given degree of certainty (e.g. 95%). (Khan et al. 2003)</i>
<i>Confounding</i>	<i>A situation in studies where the effect of an exposure on an outcome is distorted due to the association of the population and outcome with another factor, the confounding variable, which can prevent or cause the outcome independent of the intervention. It occurs when groups being compared are different with respect to important factors other than the exposures under investigation. (Khan et al. 2003)</i>
<i>Cross-sectional study</i>	<i>Examination of the relationship between disease and other variables of interest as they exist in a defined population at one particular time. (NHS Centre for Review and Dissemination 2001)</i>
<i>Effect</i>	<i>Effect is a measure of the strength of association between an intervention or exposure and an outcome. The direction of effect indicates a beneficial or a harmful effect. The point estimate of an effect tells us about direction and magnitude of the effect. The precision of effect relates to the degree of uncertainty in the estimation of effect that is due to the play of chance. See 'confidence interval'. (Khan et al. 2003)</i>
<i>Experimental study design</i>	<i>A study in which some conditions, particularly decisions concerning the allocation of participants to different intervention groups, are under the control of the investigator. (NHS Centre for Review and Dissemination 2001) These could be randomised controlled trials, quasi-experimental studies, etc.</i>
<i>External validity (generalisability, applicability)</i>	<i>The extent to which the effects observed in a study are applicable outside of the study. (NHS Centre for Review and Dissemination 2001)</i>

<i>Heterogeneity</i>	<i>Heterogeneity is the variation of effects between studies. It may arise because of differences in key characteristics of their populations, interventions and outcomes (clinical heterogeneity), or their study designs and quality (methodological heterogeneity). (Khan et al. 2003)</i>
<i>Internal validity of observed effects</i>	<i>The confidence that the study results are likely to approximate to the truth (Khan et al. 2003). It is a prerequisite for external validity.</i>
<i>Obesogenic environment</i>	<i>Aspects of the environment that encourage dietary or physical activity behaviour that increases the risk of obesity (Branca et al. 2007:13)</i>
<i>Observational study design</i>	<i>A study in which natural variation in interventions or exposure among study participants is investigated to explore the effect of the interventions or exposure on health outcomes. (NHS Centre for Review and Dissemination 2001) These could be cohort studies, case-control studies, cross-sectional studies, before-and-after studies, etc.</i>
<i>Quality assessment instruments</i>	<i>Quality assessment instruments are usually based on individual aspects or components of study design, conduct and analysis for which there is theoretical evidence of bias. These items can be assembled into a checklist, which can be used to systematically evaluate each study. Assigning numerical values to checklist items creates a scale. (NHS Centre for Review and Dissemination 2001)</i>
<i>Quality items</i>	<i>Individual aspects of study methodology, e.g. allocation concealment, blinding, follow-up, etc., which have a potential relation to bias in estimation of effect. (NHS Centre for Review and Dissemination 2001)</i>
<i>Quality scales</i>	<i>Instruments based on a number of quality items, which are scored numerically to provide a quantitative estimate of overall study quality. All scoring systems tend to be subjective. Scores can be generated by weighting all items equally or by assigning them different weights in relation to their perceived importance. (NHS Centre for Review and Dissemination 2001)</i>
<i>Quasi-experimental study design</i>	<i>A study in which the allocation of participants to different intervention groups is controlled by the investigator but the method falls short of genuine randomisation and allocation concealment. (NHS Centre for Review and Dissemination 2001)</i>
<i>Randomised controlled trial</i>	<i>Follow-up of participants randomly allocated to intervention or control groups, with a comparison of outcome rates during the time covered. Randomisation (with concealment of allocation sequence) avoids bias because both known and</i>

	<i>unknown determinants of outcome are on average evenly distributed between intervention and control groups. (NHS Centre for Review and Dissemination 2001)</i>
<i>Sensitivity analysis</i>	<i>Sensitivity analysis involves repetition of an analysis under different assumptions to examine the impact of these assumptions on the results. (Khan et al. 2003)</i>
<i>Sensitivity (recall) of a literature search</i>	<i>Sensitivity is the proportion of relevant articles identified by a search strategy expressed as a percentage of all relevant articles on a given topic. It is a measure of the comprehensiveness of a search method, i.e. its ability to identify all relevant articles on a given topic. Highly sensitive strategies tend to have low levels of precision (in that a large proportion of articles they retrieve are not relevant to the question posed) and vice versa. (NHS Centre for Review and Dissemination 2001)</i>
<i>Specificity (precision) of a literature search</i>	<i>Precision is the proportion of relevant articles identified by a search strategy expressed as a percentage of all articles (relevant and irrelevant) identified by that method. It is a measure of the ability of a search to exclude irrelevant articles. (NHS Centre for Review and Dissemination 2001)</i>
<i>Study quality (methodological quality)</i>	<i>The degree to which a study employs measures to minimise biases, focussing on internal validity; a set of parameters in the design and conduct of a study that reflects the validity of the outcome, related to the external and internal validity and the statistical model used. (NHS Centre for Review and Dissemination 2001)</i>
<i>Validity of the review</i>	<i>The validity of the review refers to the methods used to minimize bias. Bias will either exaggerate or underestimate the true effect being sought in a review. Poor searches contribute to bias as they may preferentially identify studies with particularly positive or particularly negative effects.</i>

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# 1 Introduction

Overweight and obesity are a major health risk with serious consequences to the individual's health, the economy and the public health system. The rise in prevalence of overweight and obesity in OECD countries in the past 30 years has been epidemic, with the burden imposed by obesity likely to grow substantially as prevalence rates keep increasing. It is commonly accepted today that the cause for the sharp rise in prevalence observed is most likely to be sought in the context of the environment. While we do know that context matters, there is still a lack of systematic knowledge regarding the impact of the context on individual decisions and behaviour – i.e. how and when context matters, and how it may affect the effectiveness of prevention strategies. In order to halt or even reverse the current obesity epidemic, it is fundamental to learn what structural factors in the environment in fact play an important role and which do not. This knowledge will disclose ways and potential to control and shape some of these contextual factors and to create an environment supportive of healthy behaviour.

In order to systemize the existing knowledge in this field we will conduct a literature review on the evidence regarding the contextual/environmental determinants of overweight or obesity. The review takes up an economic perspective, placing the micro-economic model at the core of individual decision making and behaviour. The aim of this study is to find answers (and research gaps) why the occurrence of obesity has suddenly and sharply risen over the past approximately 30 years in high-income countries, and why certain groups in the population tend to be more overweight than others.

Simply stated, obesity results from an energy imbalance between calory intake and calory expenditure by physical activity and metabolic processes. For overweight and obesity, Delgrande Jordan et al. (2007:6) refer to four main groups of acknowledged etiological factors: “biological factors” such as gender, age, neuroendocrine factors and genetic predisposition; “iatrogenic factors” (when weight gain may be caused by medication); “behavioural factors” determined by complex socio-psychological determinants such as habits, emotions, attitudes, parental feeding practices and strategies, beliefs, etc.; and the “environment”, i.e. the individual's physical, economic and sociocultural surroundings which in turn influence individual behaviour.<sup>1</sup> All of these factors in combination are a likely source for the existence of obesity. There is, however, a continuing debate about the relative importance of each cause. It is generally accepted that obesity is primarily caused by a latent biological susceptibility interacting with a quickly changing environment (Butland et al. 2007), thus placing the “bio-

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<sup>1</sup> Conceptually similar, the Foresight Programme differentiates between 5 causes of obesity: biology, impact of early life and growth patterns, behaviour, the living environment, and economic drivers of food and drink consumption (Butland et al. 2007). The Foresight Programme developed a comprehensive ‘whole systems’ view map which was designed as a conceptual representation of the interdependencies of relevant variables that currently determine the energy balance, and to capture this complexity and help unravel some of the interrelationships and relative importance of various determinants. It was constructed using detailed advice from a large group of experts drawn from several disciplines (Butland et al. 2007).



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logical factors” and the “environment” of the four factors listed by Delgrande Jordan et al. in the centre of attention. The human biology evolved in times of unstable and uncertain food supply and hard labour. Arising from the will to survive, millions of years of evolution have led to preferences for foods with high energy density (with the goal to accumulate energy reserves for an uncertain future) and for physical inactivity (Hill et al. 2004). This biological drive ensured an energy balance in former environments. However, environments have changed substantially in recent years to become one of food abundance and sedentariness, largely due to advancements in technology.<sup>2</sup> In response to famines and hard labour, human effort has been committed to progress to ensure food availability and to become disencumbered from hard labour. Unfortunately, our biology is maladaptive to the rapidly changing environment, and overeating and overweight have become a manifestation of a fundamental mismatch between ancient environments and modern environments (Rosin 2008:624).<sup>3</sup>

Unlike the environment, the genetic makeup of individuals has hardly changed enough in the past decades to possibly explain the recent rise in obesity rates as much of the rise has spanned less than a single generation. While biology may explain cross-sectional differences between individuals (e.g. by gender, age, ethnicity, etc.), they are unlikely to explain the sharp rise in obesity that has been observed worldwide since the 1970s/80s, because the rapid increase has occurred in too short a time for there to have been any significant genetic or biological changes that could explain the increase (Anderson and Butcher 2006a:25; Philipson 2001:3; WHO 2000:118; Wilkinson and Marmot 2003:7).<sup>4</sup> Likewise, individual preferences, which can be said to be reflected in “behavioural factors” as listed by Delgrande Jordan et al., have probably not changed substantially in the last decades, either. After all, it is possible that we still follow ancient embedded preferences of accumulating energy

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<sup>2</sup> Admittedly, food supply has been rather constant since more than a few decades: “Archaeological evidence tells us that humans began the transition from foraging to subsistence agriculture around 10,000 years ago, and this is almost certain to have represented an increase in food security.” However, the globalization and technological advancements of recent decades have expanded this constant food supply to an *abundant* food supply for western industrialized countries. “But smallscale agriculture in the absence of inter-regional trade was still subject to devastating climatic fluctuations, and historical records bear this out (Irish Potato Famine 1849, Great Famine 1315-21, and further famine events in 1816-18, 1740, and 1693-94).” (Smith 2002:39)

<sup>3</sup> However, it is important to remember that the long-run increase in weight is essentially part and parcel of a long-run improvement in health and nutrition (Costa and Steckel 1995).

<sup>4</sup> On one hand, “[...] it does appear that certain people may have a higher genetic susceptibility to weight gain. Thus, when identical twins are subjected to an overfeeding regimen, the correlation of the weight gain within twin pairs is significantly higher than that between twin pairs. But as important as genes are, the primary focus in the search for the causes of rising obesity must be on changes in energy balance” (Anderson and Butcher 2006a:25). But on the other hand there is evidence from natural experiments supporting the argument that one’s environment is the key factor driving body weight: One is found with the Pima Indians, who divided when one group migrated to Arizona and the other stayed in Mexico. Today, the Arizona Pimas weigh significantly more than their Mexican counterparts. In another study of siblings from Punjab, India, of whom one remained in India and the other migrated to a western culture, it was found that the siblings who remained in India had substantially lower average BMIs (Schwartz and Brownell 2007:80).

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reserves for an uncertain future, or a “phantasmic food shortage” (Smith 2002:40), for example in our taste preferences for sweet and fatty foods. Likewise, economics often makes the assumption that preferences are stable, see e.g. Rosin (2008) for some illustrations. On the other hand, preferences may be shaped by other factors apart from the Darwinian struggle to survive, such as attitudes shaped by social influences, a culture’s ideal of beauty, and perceived behavioural control. It is very well possible that some of these aspects have changed in the past decades, and may be a source of the recent obesity rise. Nevertheless, we argue that those changes have been negligible in relation to the observed obesity epidemic and that “behavioural factors” are more likely to explain cross-sectional differences, just like the “biological factors”. As to the “iatrogenic factors”, while they may also help explain why some groups of the population (e.g. those taking a specific medication) are overweight and others are not (cross-sectional differences), they give no explanation with respect to the population-wide rise in obesity rates.

Therefore, to answer why the population-wide occurrence of obesity has suddenly and sharply risen over the past approximately twenty-five years, we argue that the causes must thus be sought in the environment. In fact, as this literature review is to highlight, the rapid increase in obesity rates is emphasised by many authors to be related directly to fundamental changes in the aspects of our obesogenic environment in shaping our physical activity and food consumption patterns.<sup>5</sup> The OECD Expert Group on Economics of Prevention (2008:13) find indication for obesogenic environments in their age-period-cohort analysis, reflected as a strong positive period effect of the past 20-30 years on obesity time trends.

With regard to why certain groups in the population are particularly susceptible to overweight it is obvious from the discussion above that all four factors as listed by Delgrande Jordan et al. are certainly relevant to explain cross-sectional differences. The perspective of the review at hand being economic, i.e. focussing on individual decision-making and behaviour, there are nevertheless certain limitations. First, the “biological factors” and “iatrogenic factors” listed by Delgrande Jordan et al. (2007:6) mainly refer to aspects of the metabolic processes influencing the energy balance, they do not affect individual behaviour explicitly. Therefore, they are preferably studied with a medical and biological perspective rather than with an economic perspective. Second, while the “behavioural factors” influence the energy balance through individual behaviour (as opposed to metabolic processes) and are thus linked more closely to economics than the “biological factors”, economics regards these “behavioural factors”, or preferences, generally as given and offers no explanation for how preferences evolve and are formed, see e.g. Becker (1976). Other disciplines, such as psychology and sociology, are better apt to explain how and to what extent these

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<sup>5</sup> Also see for example the statement by Wilkinson and Marmot (2003:7): „But however important individual genetic susceptibilities to disease may be, the common causes of the ill health that affects populations are environmental: they come and go far more quickly than the slow pace of genetic change because they reflect the changes in the way we live. This is why life expectancy has improved so dramatically over recent generations; it is also why some European countries have improved their health while others have not, and it is why health differences between different social groups have widened or narrowed as social and economic conditions have changed.”

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behavioural factors can influence health-related behaviour. In fact, the existing evidence indicates that this field is relatively well-analyzed: Swinburn et al. (1999:564) argue that the biological and behavioural influences have attracted the most attention with respect to causes, treatment, and prevention of obesity, and van der Horst et al. (2007:203) state that “the research of determinants of dietary intake in children and adolescents [...] has predominantly focused on individual level determinants of these behaviours, such as attitudes, taste preferences, social influences and perceived behavioural control”.

Consequently, from the standpoint of economics, the determinants to be analyzed with regard to cross-sectional differences of obesity risk in the population are also to be sought in the environment.

In the present literature review we aim at systematizing the existing knowledge regarding the determinants of overweight or obesity. With the micro-economic model being placed at the core of individual decision making and behaviour here, this review concentrates on the contextual/environmental factors as the critical determinants of the sudden sharp rise in obesity and the systematic discrepancies in overweight risk among certain groups in the population. The environment provides incentives and disincentives for certain individual decisions, and can thus encourage or discourage physical activity and healthy eating. Plainly speaking, if eating and physical activity behaviour determine the observed energy imbalance to a large extent, one can be tempted to conclude that the problem of rising obesity rates has a simple solution, namely to eat less and exercise more. However, there are intricacies inherent in how individuals acquire and use energy. This underlying complexity to obesity is what we aim to unravel with this literature review.

Before defining the review question and review methods we shall present and discuss our theoretical framework of the review. This will help to thoroughly comprehend the search strategy and inclusion/exclusion criteria of the review.

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## 2 Theoretical background

The following paragraphs offer some insight on various aspects of the theoretical foundation of the review question. In particular, we discuss aspects on the micro-economics of obesity (2.1), the concept of environment used in this review (2.2), a model formalizing the public health perspectives of overweight (2.3.1) and the micro-economic aspects of overweight (2.3.2), and on the static and dynamic perspective of the review question (2.4).

### 2.1 The micro-economics of obesity

The fundamental question before setting up this literature review was why to integrate economics into research on the dynamics of obesity prevalence. There are two main reasons why economics is becoming an important discipline in the obesity epidemic research.<sup>6</sup> One reason is that economics provides a set of analytical techniques and quantitative methods. Another reason is that economics provides a way of thinking about individual behaviour. Economics has been described in various ways, but most commonly as „the study of choice“. Indeed, the micro-economic model is focused on individual decision making, which is manifest in individual behaviour. Ever since Gary Becker started to take the ideas of economics and apply them to behaviours generally considered “far from the realm of dollars and cents” (Knickman and Orleans 2004:175), economics is considered a truly social science, see e.g. Becker (1976) and Frey (1990). With obesity largely being a behaviour-based risk factor (physical activity and eating behaviour), it seems worthwhile to analyze it micro-economically.

The core concept of human nature and human behaviour in economics markedly differs from other social sciences such as psychology or sociology. Therefore, economics and the economic way of thinking may contribute valuably to other science’s findings. An interdisciplinary approach seems most prolific to address a problem as complex as obesity.

#### 2.1.1 The economic way of thinking: rational choice

The micro-economic model of individual behaviour is based on the notion that individuals have a set of preferences. Generally, these preferences state that “more is better”, i.e. the benefits increase with the amount consumed. However, “more” is not infinitely feasible, because people face restrictions, i.e. limits with respect to their budgets, their time, their human and social capital, the available technology, etc. These restrictions introduce the notion of scarcity. This relative scarcity of the available resources in view of the unlimited wants poses the problem of choice and trade-off decisions to the individuals.

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<sup>6</sup> McCarthy (2004:2169) states: “So Hill and other researchers working on the obesity epidemic have begun to enlist the help of economists. „I am convinced that we won’t understand why we have an obesity epidemic or learn how to deal with it until we figure out the economics of it all“, Hill says.”

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In view of this scarcity and the trade-offs, how is an individual supposed to behave? The theory of rational choice states that individuals behave rationally. This means that the individual acts in its self-interest by maximizing the benefits relative to the costs, given the preferences and restrictions in terms of income, time, prices, etc. In other words, individuals choose the alternatives with the largest ratio of benefits to costs.<sup>7</sup> In this decision-making, (relative) prices obviously constitute a crucial concept.<sup>8</sup> It is important to acknowledge the conceptually rather broad definition of price in economics: this so-called opportunity cost of an alternative includes not only the monetary price attached to a product or service but also the time and other costs (e.g. risk) associated with consuming it (Propper 2004:987). Closely linked to the price is the idea of incentives: a change in the relative price of an alternative represents a change in incentives to choose that alternative.

Correspondingly, body weight is the result of a multitude of economic decisions affecting behaviour. These decisions involve market transactions directly, e.g. via the purchase of food or labour-saving devices such as cars. In view of limited income, an individual will normally buy food that represents the best value for the price. And if the price of a car in relation to the income decreases, more people buy cars. The decisions also involve market transactions indirectly, e.g. via the allocation of scarce leisure time to physical activity or preparing healthy dinners. Time is money, thus as real wages rise, for example, the opportunity cost of the *time* required to prepare and eat freshly prepared, nutrient-rich foods rises, making calorie-rich fast food meals relatively less expensive (Smith 2002:7). In economics, this is termed substitution effect. If real wages rise, however, people may alternatively decide to spend less time working and more time (instead of less) preparing fresh meals and exercising because they can subsist with less work time; this is termed income effect.

The body weight, in turn, can also influence the costs and benefits associated with an alternative. For example, the costs of physical exercise increase with weight because it becomes more strenuous. Likewise, it is sometimes argued that the benefits of eating increase with body weight: Eating may be addictive so that past eating makes it

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<sup>7</sup> We find it worth making the following note with respect to the applicability of the rational choice theory and the assumptions regarding the decision making in general to the case of obesity. The rational choice theory builds upon consumers who intend to behave rationally by maximizing their satisfaction from food given their personal constraints. This does by no means imply that there is no addiction to certain foods, that people behave rationally and understand the trade-off between short-term pleasure and long-term health consequences, that they have self-control at all times, that they behave time-consistent, etc. In fact, by highlighting how the environment impacts on consumers' choices, we will be able to disclose that time-consistent behaviour and self-control over the own behaviour become increasingly difficult in an environment that more than ever resembles a land of milk and honey. However, while a lack of the validity of these assumptions is a rationale for government intervention, it does not influence the validity of the fact that incentives and disincentives guide individual behaviour and that changes in the incentive structure of the environment can explain changes in the behaviour.

<sup>8</sup> "Prices and other market instruments allocate the scarce resources within a society and thereby constrain the desires of participants and coordinate their actions. In the economic approach, these market instruments perform most, if not all, of the functions assigned to "structure" in sociological theories." (Becker 1976:5)

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necessary to eat more today and thus raises the utility of current eating (so called rational addiction).

At first sight, the micro-economic model seems to underexpose the importance of environmental factors other than time costs and monetary prices. However, people face incentives and restrictions in more aspects of the environment. If technological progress such as the introduction of elevators makes taking the stairs relatively more costly in terms of time or physical exertion, people will switch to using the elevators. If a city provides a well-kept park or sports field, it may become less costly in terms of safety and more enjoyable to go running in the leisure time. If the sedentary recreation options (TV, computer games, internet, etc.) are becoming more interesting, using scarce leisure time for physical activity is becoming relatively costly in terms of lost amusement. Alternatively, “a society that places a premium on thinness could be interpreted as placing a higher implicit “price” on an extra pound of body fat” (Smith 2002:7).

Thus, changes in eating and physical activity patterns are plausibly driven by changes in the environment as they provide incentives or disincentives. There is likely to be a multitude of factors in the environment that may play a role, some of them encouraging thinness, others encouraging overweight, and overall presumably leading towards an increasing asymmetry in the ease of consuming additional energy compared to the difficulty of expending it.<sup>9</sup>

### **2.1.2 Preferences and restrictions**

The two key elements of the micro-economic model of individual behaviour are the preferences and the objective possibilities or restriction.

Preferences are very difficult to capture. They can be said to be shaped by “behavioural factors” and long-term biological drives. Alternatively, our environments may evolve according to human preferences and biological imprints: “Millions of years of evolution have led to preferences for foods with high energy density and for physical inactivity. Consequently, social and economic systems have evolved to provide convenient and inexpensive energy-dense foods, to remove the need for physical activity in daily life, and to provide attractive sedentary entertainment options” (Hill et al. 2004:111). It becomes clear how complex the concept of preferences is. Economics does not offer any explanations for how preferences evolve and are formed. Instead, preferences are regarded as given. What is more, for simplicity we will assume (as is common in economics) that preferences are robust and stable over time.<sup>10</sup> Thus, we

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<sup>9</sup> In terms of body weight, this tendency is a step away from the Ottawa Charter for Health Promotion (WHO 1986:2) as it does not make the healthy choice the easy choice. However, the same changes in the environment are essentially part and parcel of a long-run improvement in health and nutrition, and everyday living. In this review we will not weigh the benefits of these changes against their costs (in terms of their contribution to the obesity epidemic). We will not make any normative statements in this review.

<sup>10</sup> Obviously, the possibility of preference shifts over time is not easily dismissed in the context of weight-relevant behaviour. Both longitudinal and cross-cultural comparisons indicate that people had and still have differing beauty ideals. Moreover, progress in medical treatments may have changed the

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will not analyze the influence of preferences on the obesity-relevant choices of individuals.

The restrictions of options or the range of possibilities, respectively, that individuals face when making choices are manifold. In fact, as seen above, anything in an individual's surroundings and environment can influence his or her scope for possibilities. Restrictions can amply be summed up as all the relevant factors in the "environment". Paragraph 2.2 gives a more detailed definition of the concept of environment applied in this review.

## 2.2 The environment (PESTEL framework)

The concept of "environment" used in this literature review is extensive, as it is to contain 'anything outside the individual'. The environment is structured to enclose a political/legal, an economic, a sociocultural, a technological, a physical/natural and a policy environment domain, in accordance with the PESTEL framework.<sup>11</sup> The PESTEL framework is an instrument used in strategic management to identify key issues and ways of coping with complexity and change in an organisation (Johnson et al. 2005); organisations are similarly influenced by factors from the environment and therefore management sciences have developed ways to describe, explain and analyze them. Likewise, it can help to build up an understanding of how changes in the environment are likely to impact an *individual's* behaviour (as opposed to the behaviour of organisations). This broad perspective recognizes the multifaceted contributions of the environments in which people live and work and interact, and it evokes a broad array of resources in the environment that may be leveraged to improve poor health outcomes.

In relation to obesity, the factors in the environment that may exert an influence on weight-relevant individual behaviour have been coined 'obesogenic'. Obesogenic environments can be defined as all aspects of the environment that encourage die-

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incentives to maintain a healthy body weight and a healthy lifestyle in general by attenuating the adverse health consequences. In turn, both public health and entire industries may have influenced preferences by promoting healthy foods, gyms and sports through advertising and awareness campaigns. Evidently, there are also innumerable industries advertising foods and devices that are unfavourable to a healthy lifestyle. Hence, the possibility of preference shifts in this context is far from being implausible. However, many of these factors work in the opposite direction of what is indeed observed in the rising prevalence rates. In particular, they are not necessarily apt to explain the sudden, steep prevalence increase witnessed in the past approximately 25 years.

<sup>11</sup> An alternative to the PESTEL framework as a classification system to order the complexity of potential determinants of obesity in the environment is the ANGELO framework ("ANalysis Grid for Environments Linked to Obesity") proposed by Swinburn et al. (1999). The types of environments distinguished in the ANGELO framework are the physical, sociocultural, economic and political environment. The PESTEL model is therefore largely compatible with the ANGELO framework but further accounts for a technological and legal environment, which are potentially important dimensions. The Ottawa Charter for Health Promotion (WHO 1986:1) also stated that "political, economic, social, cultural, environmental, behavioural and biological factors can all favour health or be harmful to it", and they added a discussion on the importance of legislation (WHO 1986:2) and technology (WHO 1986:3).

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tary or physical activity behaviour that increases the risk of obesity (Branca et al. 2007:13).

Similar to Egger and Swinburn (1997), we further dissect the obesogenic environment according to size (or proximity to the individual) and differentiate between the micro-level, meso-level, and macro-level:

- Micro-level environment is characterised by an immediate proximity to the individual and combines the family, the household and close friends.
- Meso-level environment is characterised by a somewhat broader setting, and includes the neighbourhood or community, and organizations such as schools, the workplace, etc.
- Macro-level environment combines the overarching systems or sectors, such as the society in general and influences from the globalized world, a nation's government/education/health/economic system, the food industry, etc.

There are two main reasons for this differentiation. First, it is sometimes argued that the proximity of the environment also influences the degree to which it is amenable to the control of individuals. For example, an individual may not be able to influence state regulations regarding school food or physical education (PE) requirements, but an individual can buy healthy food for the home or choose to live in a neighbourhood with good possibilities for physical exercise. However, this argument is only partially apposite because even on the environment's micro-level, economic restraints, for example, can defy the control over the immediate environment. The second reason relates to the extent with which a factor explains the variation in the risk of overweight at each level. An aggregate variable for economic prosperity such as a country's gross domestic product (GDP), for example, may explain differences in obesity rates between countries, but it will not explain why some individuals within a country are overweight and others are not. Likewise, since there are socioeconomic differences among families all living in the same neighbourhood, an indicator measuring neighbourhood deprivation will not help explain why some families in the neighbourhood have weight problems and others do not. Thus, depending on the research question to be answered, the analysis needs to concentrate on a different level of environment: when analyzing the risk of overweight on an individual level, e.g. a population within a neighbourhood, micro-level environment factors are probably the most relevant determinants since the meso-level and macro-level determinants exhibit barely any variation. Likewise, if country differences in overweight prevalence are to be analyzed, it is probably redundant to include micro-level environment factors.

In this context it is important to acknowledge that variables seemingly measuring the same (e.g. economic prosperity) at different levels (individual income, neighbourhood, GDP) may in fact measure a slightly different construct, see in particular the work by Schwartz (1994).

The complexity of the environmental influences on overweight is somewhat reduced by the two-dimensional structure (or matrix) of the kind of environment (political/legal, economic, sociocultural, technological, physical/natural and policy) and the size of



the environment (micro, meso, macro). This matrix will be utilized for the synthesis of the review results (chapter 5).

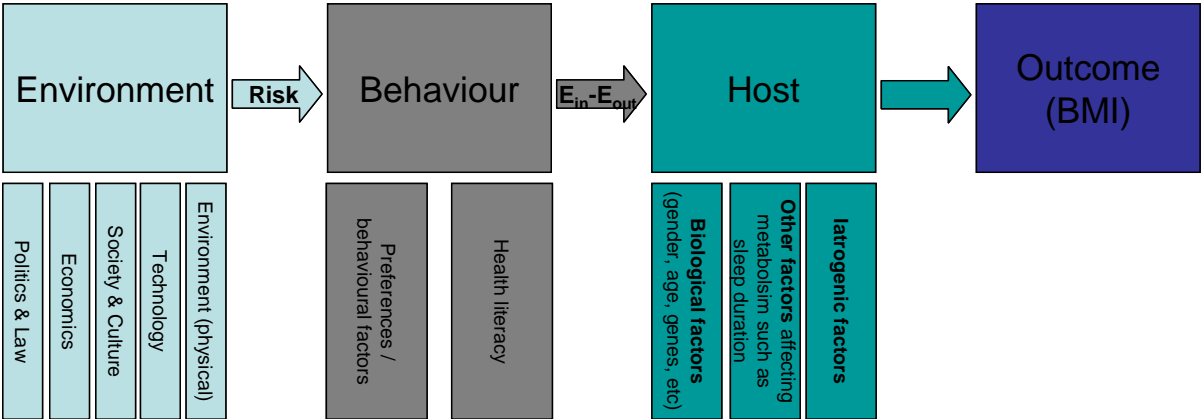
### 2.3 Model

In the following we propose two models to formalize the background of this literature review. One models takes a general public health perspective, the second one is a micro-economic model.

#### 2.3.1 ‘Public health’ model

For the impact of the environment on the overweight outcome we propose the following model, which we base on the work of Egger and Swinburn (1997) and Swinburn et al. (1999) on the one hand and on a causal path model presented elsewhere on the other hand (Schmidhauser et al. 2008):

**Figure 1** Public health’ model



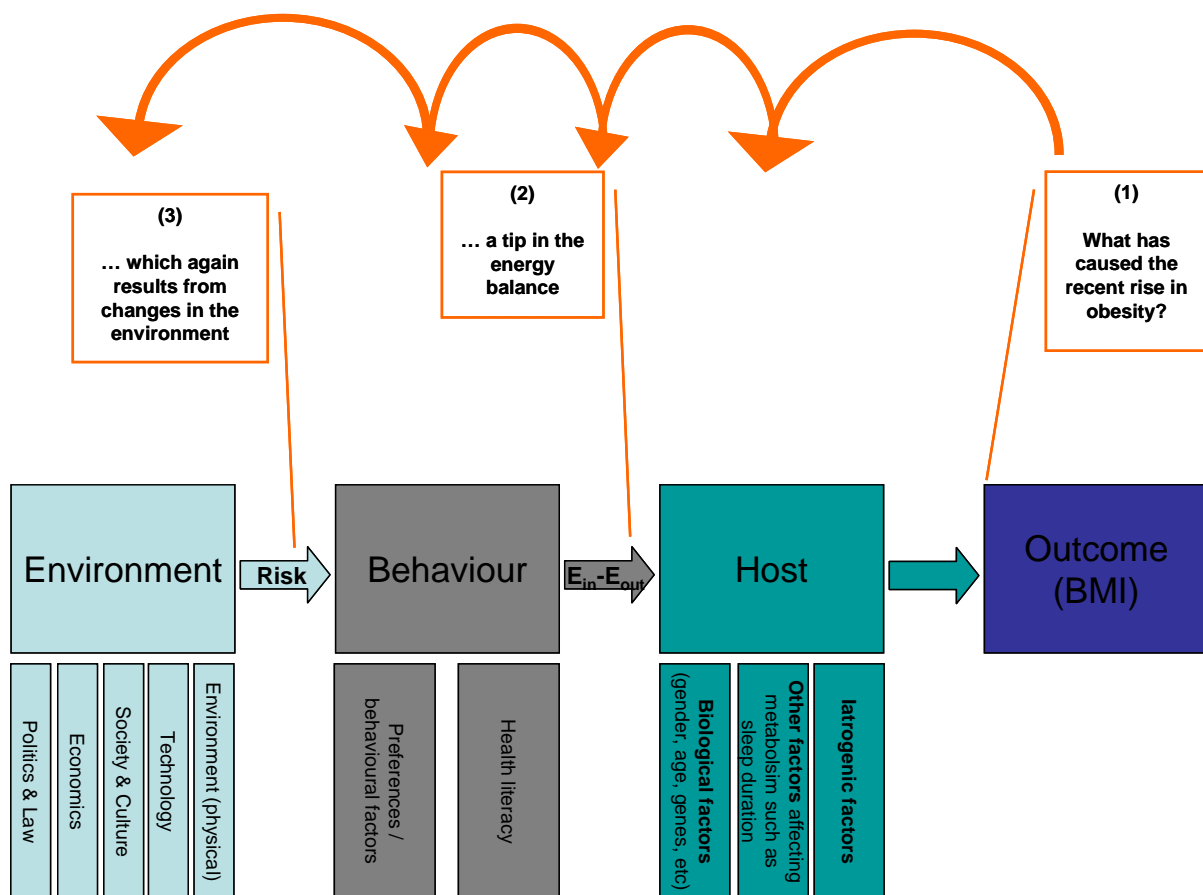
The above figure illustrates the following: Individual behaviour (dark grey box) is based on the two pillars *preferences / behavioural factors* and *health literacy*, which we regard as exogenous. Over and above that, the environment (light blue box) influences behaviour by providing a multitude of incentives and disincentives that encourage or discourage certain behavioural patterns. The environment thus can constitute a risk for unhealthy behaviour. This risk is aggravated by insufficient health literacy and unhealthy preferences, but it poses a risk independently of these two pillars (i.e. even individuals with high health literacy and a preference for very healthy lifestyles can be encouraged to unhealthy behaviour by the environment).<sup>12</sup> The individual’s body can curb or aggravate the health consequences of the energy balance (energy in minus energy out  $E_{in}-E_{out}$ ) resulting from behaviour. This means that the final health outcome (measured in BMI, e.g.) can vary between different individuals,

<sup>12</sup> Also, individuals can exercise resistance to the development of obesity, behaviourally, through cognitive restraint of food intake. Likewise, groups can exercise resistance culturally, by way of practices which either restrict food intake or maintain physical activity, or maintain embodiment ideals that carry moral or status valency (Ulijaszek 2007:445).

the so-called hosts (dark green box), for the same behaviour. This is due to variations in the genetic make-up, and other factors influencing the metabolic rate of an individual such as medication, sleep duration, current body weight, varying energy use of physical activity, etc. Together, the preferences, the health literacy, and the host can be summed up to 'what's inside the individual', as opposed to the environment which is 'what's outside the individual'.

By means of backward induction the model helps isolate the key factors that are responsible for the recent population-wide obesity epidemic and reasons for cross-sectional differences among different groups in the population at one point in time. The process goes as follows (see Figure 2): The recent rise in obesity is unlikely to be caused by a sudden change in biological, iatrogenic or other factors affecting the metabolic rate (Anderson and Butcher 2006a:25; French et al. 2001; Hill and Peters 1998; Philipson 2001:3; WHO 2000:118; Wilkinson and Marmot 2003:7).

**Figure 2** Backward induction in the 'public health' model



Poston and Foreyt (1999) review the evidence (including some anecdotal evidence drawn from natural experiments) and are able to support the importance of the environment in the development of obesity. Therefore, we take one step back to the energy balance to find the cause of the obesity epidemic: what made the energy bal-

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ance tip? Reasons may be sudden changes in health literacy, preferences and other behavioural factors, or changes in the environment. Preferences may not have altered substantially towards unhealthier lifestyles in the past decades (Smith 2002), and are thus an improbable cause for the rise in obesity. Regarding changes in health literacy as a potential cause, there are two threads of arguments. On one hand, health literacy is generally unlikely to have deteriorated in the past decades, especially in view of the increasing possibilities and efforts spent for information dissemination by public health authorities. On the other hand, the food market is considered more dynamic today than it was some decades ago, with new foods being launched in the market. In terms of health literacy, it may then simply become difficult for individuals to catch up with the fast developing food market. Therefore, while the stock of individual's health literacy is not necessarily shrinking, it is not growing at the pace the changing environment would require it to. In addition, the private market gives food manufacturers an incentive to disseminate information on their products that may counter the information given by public health authorities or are not necessarily fully transparent to the consumer (such as claims that the product is 'light', 'fat-free', 'sugar-free', etc.). While it is certainly important to consider health literacy as a crucial factor in the recent obesity epidemic, much of the debate around health literacy may be traced back to a rapidly changing environment. Therefore, the positive energy balance  $E_{in}-E_{out}$  is to a substantial part the result of a changing environment that poses a larger risk for a behaviour favouring a positive energy balance (Butland et al. 2007:43; Sasso et al. 2009:15).

The backward induction does not provide a solution nearly as unambiguous with regard to the reasons for cross-sectional differences among different groups in the population at one point in time. Host factors, as well as preference and health literacy, and the environment are possible sources for the variation in the risk of obesity.

Regarding the current body of evidence, there clearly exists a large body of descriptive evidence regarding the actual situation or trend over time of the environment, the health literacy, the preferences (behavioural factors), the host factors and the outcome. Regarding causalities or associations, considerable evidence exists in the medical literature with respect to the influence of the host factors on the outcome (BMI) (see for example Bray and Bouchard (2004) for the influence of physical activity and eating behaviour on body weight status, or one of the many effectiveness reviews such as the one by Summerbell et al. (2005), Faulkner (2009), Gibson (2008) or Bravata et al. (2007). There also exists evidence of the influence of certain aspects of the environment on physical activity or eating behaviour (see e.g. reviews by French et al. (2001), Popkin et al.(2005) and van der Horst et al. (2007). Thus, theoretically, it should be possible to draw the link between environment and outcome because there is evidence regarding the single causal paths. But given all the possibilities for 'compensating behaviour' (eating more when exercising a lot, or compensating decreasing transport-related physical activity with more leisure-time physical activity) and other mediating factors between environment and outcome, this is critical. The chain as drawn in the figure above gives a plausible underpinning of the hypotheses, a story, but no evidence. Therefore, in this review we concentrate on the evidence regarding the direct link between environment and outcome to under-

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mine the hypothesis of a causal chain. From a statistical point of view this is a challenge for several reasons (Schmidhauser et al. 2008) among them the simple fact that all the mediating factors can work as confounding factors in an empirical analysis.

### 2.3.2 Micro-economic model

Cawley (2004) proposed an economic model called SLOTH for understanding the recent rise in obesity. It is based on the study of how people allocate their scarce resources of time and money in order to maximize their lifetime happiness. It is important to recognize that health is only one factor that contributes to people's happiness, and the maximization of health is not necessarily a goal for individuals: "Sometimes people are willing to sacrifice health in exchange for other things that they value." (Cawley 2004:117)

The economic framework presented assumes that individuals seek to maximize their happiness which is influenced by

- time-consuming activities SLOTH: Sleep, Leisure, Occupation (paid work), Transportation, and Home production (unpaid work).
- body weight  $W$  (which is again influenced by SLOTH and food consumption  $F$ )
- health  $H$  (which is again influenced by SLOTH,  $F$ , and  $W$ )
- other factors  $Y$

The economic view is that people are involved in the production of their own health and happiness. People combine their time (e.g., to get exercise) with market goods such as food, health care, tobacco, and alcohol to improve, maintain, or ravage their health.

Clearly, more of everything will always be better. But in a world of scarcity, all these variables are subject to constraints. Specifically, there are the constraints of time (i.e. 24 hours per day), budget (i.e. financial resources), and biology (i.e. weight will rise when caloric intake is high relative to calorie expenditure).

An individual cannot directly choose a level of health or happiness, but only indirectly through their behaviour. That is, the main parameters the individual can control are physical activity (influenced by the SLOTH pattern) and caloric intake  $F$ . Higher caloric intake will probably increase utility directly, decrease utility indirectly by increasing body weight, and decrease utility indirectly by decreasing health status. Physical activity can both increase and decrease utility directly (leisure-time physical activity probably increases utility if it is regarded as fun and wellness, and occupational or transport-related physical activity probably decreases utility because it means less convenience and comfort), less physical activity decrease utility indirectly by increasing body weight, and decrease utility indirectly by decreasing health status. These are the tradeoffs an individual faces in everyday life.

In a multi-period version of the framework, individuals' decisions about eating and time allocation in each period should reflect both the immediate and the future con-

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sequences of the decisions (where individuals typically assign less importance to outcomes in the distant future than to those in the present): For the decision whether to eat a fast-food meal, for example, the immediate benefits include the instantaneous pleasure of eating, and the immediate costs include the monetary cost of buying the food (and thus not being able to spend that money on other items). But there are also future costs involved, namely the utility loss from higher future weight, and the utility loss from any adverse future health consequences. (Cawley 2004:119)

According to the microeconomic theory, a person will have allocated his money and time optimally, when there is an equal increment of utility for the last hour spent in S, L, O, T and H, net of the utility costs associated with engaging in this activity; the same applies to caloric intake per dollar spent in optimum. (This rule is known in microeconomics as Gossen's Second Law; in this context, Cawley (2004) names it the "last hour" and "last dollar" rule). This rule is useful for considering causes of the rise in obesity. "For example, if the marginal utility provided by an hour of sedentary entertainment rose (e.g., because of an increasing number of television channels and the rise of home video games) and the marginal utility of all other activities remained constant, then the framework predicts that individuals would reallocate their time in order to spend more time in sedentary pursuits (Cawley 2004:119)". Likewise, "if the price of a certain food falls while the prices of other foods remain constant, then we would expect individuals to reallocate their budget in order to buy more of the newly-cheaper food and less of other foods until the "last dollar" rule is again satisfied" (Cawley 2004:120).<sup>13</sup>

## 2.4 Static and dynamic perspectives

We differentiate between a static perspective (using cross-sectional data) and a dynamic perspective (using longitudinal or panel data).

With the static perspective associations between environment and individual behaviour are analyzed at one specific point in time. Differences in obesity rates among subgroups of the population may either result from differences in exposures to obesogenic environments or from different preferences. Again, we will not analyze the impact of preferences on individual behaviour. Instead, it is examined whether differences in the determinants of the environment can help explain why some sub-groups in the population exhibit higher prevalence rates of overweight and obesity than others. That is, does unequal exposure to obesity-relevant environments partly explain inequality in overweight and obesity risk? After all, it is commonly agreed that "specific social groups are especially vulnerable to obesogenic environments. People with lower socioeconomic status (hereafter: SES) face structural, social, organizational, financial and other constraints in making healthy lifestyle choices" (Branca et al. 2007:13). Yet what are these constraints specifically?

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<sup>13</sup> In a static world (i.e. where neither prices nor income nor constraints change), we will still observe differences in behaviour between individuals. These differences reflect that decisions are also shaped by preferences which differ across people.

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However, preference differences among subgroups are not trivial. Particularly cultural differences must be accounted for: “In some cultures, high levels of obesity are acceptable, or even considered desirable, whereas other cultures have strong prejudice against overweight people, which may affect children as well as adults. In addition, not all cultures support physical activity of children in the same way, especially for girls” (Branca et al. 2007:29). We will therefore limit this review to studies analyzing populations from western OECD countries. Moreover, studies with a static perspective that are selected for this review should attempt to control for such cultural differences in preferences. Preference differences between subgroups may nonetheless be insufficiently accounted for. It is therefore important to critically appraise studies with a static perspective.

The dynamic perspective is taken to find associations or causal relationships between environment and individual behaviour using changes in time. In particular, can changes in the environment that occurred in the past decades help explain the sharp rise in prevalence of overweight and obesity which has been observed in OECD countries in the past approximately 30 years? Individual's resource restrictions may change over time, caused for example by a higher income, more leisure time due to reduced commuting time, lower prices, etc. According to micro-economics, this change will reflect in behaviour change because individuals rethink and adapt choices and decisions according to the new ratio of costs and benefits associated with each option. What is more, any change in behaviour observed over time is most likely due to changes in the environment since preferences (nor biological or genetic factors) generally do not change that suddenly and quickly. Indeed, “perhaps the most useful contribution of economics [...] is offering insights about why obesity rates are changing. Economic factors change, as do social factors, much more quickly than the biological and psychosocial determinants and may be disproportionately large drivers of recent changes in obesity patterns [...]” (Knickman and Orleans 2004:175).

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### 3 Review question

The review is conducted to answer the following question:

What are the environmental factors (political/legal, economic, sociocultural, technological, physical/natural and policy) that are associated with overweight and obesity in the general population in high-income countries?

We will examine both the *static* and the *dynamic* aspects of this review question:

- Dynamic aspects: Overweight and obesity prevalence have risen sharply worldwide since the 1970s/80s. What are the determinants in the environment that have contributed to the sharp rise in overweight and obesity prevalence in OECD countries in the past approximately 25 years, i.e. can changes in the environment that have occurred in the past decades help explain this sharp rise?
- Static aspects: Several studies have noted an increased prevalence of overweight and obesity among specific population groups, e.g. categorized by income level or educational attainment level (Branca et al. 2007:10). What are the determinants in the environment that make some sub-groups in the population exhibit higher prevalence rates of overweight and obesity than others, i.e. does unequal exposure to or differential access to health promoting environments contribute to inequality in health?

#### 3.1 Novel contribution of this review

How does this review contribute to the existing knowledge, i.e. how does it differ from other reviews that have been conducted in this field? (for example, Ball and Crawford 2005; Black and Macinko 2008; Booth et al. 2005; Faith et al. 2007; Ferreira et al. 2007; Frank and Engelke 2001; French et al. 2001; Handy et al. 2002; Humpel et al. 2002; Jones et al. 2007; Papas et al. 2007; Popkin et al. 2005; Saelens et al. 2003; Sallis et al. 2000; Shrewsbury and Wardle 2008; Sobal and Stunkard 1989; Story et al. 2008; van der Horst et al. 2007; Wansink 2004).

With respect to the review question, the key feature that distinguishes the review at hand relates to the outcome measure. We will confine this review to evidence on the impact of the environment on a measure of overweight and obesity as the outcome (e.g. BMI). Thus, we will not seek evidence regarding the impact of the environment solely on weight-related indicators such as physical activity and eating behaviour. The reasons for this strict focus on an outcome measure of obesity and overweight are threefold. First, there already exist extensive up-to-date reviews on the impact of the environment on physical activity and/or on eating behaviour (French et al. 2001; Popkin et al. 2005; van der Horst et al. 2007). The associations between environmental characteristics and obesity as the outcome, on the other hand, has not been well studied (Butland et al. 2007:53). Second, because looking at just one side of the coin, i.e. on either caloric intake or on physical activity, neglects the fact that individuals who eat more may compensate by exercising more and vice versa. For example, Agram et al. (2004:20) report that despite the evident importance of dietary

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intake in obesity, caloric and macronutrient intakes have been inconsistently associated with overweight both in childhood and in adolescence. Addressing the problem of the increasing imbalance between calories consumed and those expended requires examination of both energy intake and energy expenditure (Jones et al. 2007:2). Third, there are difficulties connected with the available physical activity and eating behaviour indicators, e.g. with respect to their accounting for different forms and intensities of physical activity (overt exercise vs. energy expended during daily activities, etc.), with the validity of the measurement instrument (e.g. report correct portion sizes and nutritional content in dietary intake surveys), and possible behaviour-distorting effects of the measurement itself (e.g. when wearing accelerometers which measure the number of steps a person takes).<sup>14</sup> Moreover, the lack of uniformity of the outcome indicators may make it hard to weigh different studies against each other and assess the relative importance of the analyzed determinants on the outcome indicator. The BMI overcomes (most of) these difficulties because it is a widely known and used indicator and provides a clear-cut and standardized (albeit maybe controversial) definition of overweight and obesity.

A further distinguishing aspect relates to the here applied concept of the environment. As illustrated above in the economic model, our definition of environment being 'anything outside the individual' takes a rather broad perspective by accounting for politics & law, economics, society & culture, technology, the physical & natural environment and policy. In comparison, many of the above mentioned reviews restrict their analysis on specific aspects of the environment. However, the same definition becomes a limitation with respect to psychosocial, behavioural, biological and further determinants which we consider as being part of the individual and thus not being 'outside the individual'.

With respect to the review method, the distinctive feature is the extensive literature search and the synthesis of the results. We attempt to follow the guidelines for systematic reviews (in particular those by the NHS CRD (2001)), both with respect to the literature search, the strict application of inclusion/exclusion criteria, and the way we process, present, and critically examine the results (quality assessment). As opposed to many other reviews in the field the review at hand will be more than narrative in presenting the results by also giving insight on other aspects (such as statistics on the evidence itself, and critical appraisals of the validity of the results).

### **3.2 Aims and objectives of the review**

The motivation for the literature review, as was discussed above, is the need for a more thorough understanding of what structural factors of the environment surrounding an individual (i.e. the context) influence the risk of overweight and obesity.

This review aims at filling the existing lack of systematic overview, as identified by van der Horst et al. (2007:204): "The number of studies examining the influence of

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<sup>14</sup> See e.g. the project report of the UK Foresight Programme (Butland et al. 2007:48): "Observational studies in this area are hampered by the lack of robust, objective measures of dietary intake and physical activity and by behavioural and attitudinal measures in large populations."



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environmental factors on behaviour is expanding, but there is no systematic overview of which environmental factors have been studied extensively, and what aspects of the environment are more influential than others” (see also Swinburn et al. 1999).

The first-phase aim of the literature review is to identify the factors in our environment which either favour or discourage healthy behaviour and thus determine weight-relevant behaviour from a micro-economic point of view. We account for explanatory factors in the political/legal, economic, sociocultural, technological, and physical/natural environment as suggested by the PESTEL framework if available. Thus, the systematically searched for and collated evidence is an important step in thoroughly preparing the grounds for a calculation of the returns on investment of public health efforts in the field of overweight and obesity; this information is relevant to estimate the effectiveness of behavioural interventions as precisely as possible:

- In order to improve the (cost-)effectiveness evaluations it is necessary to learn more about how the context (or environment) in which an intervention targeting individual behaviour (“Verhaltensprävention”) is delivered influences the intervention’s effectiveness. The literature review will shed more light on the relevance of an intervention’s context, on how an intervention’s effect estimate might in fact be biased by the context, and what context factors act as confounders when estimating effects without controlling for them.
- In order to prepare the grounds for a calculation of the returns on investment of public health efforts in this field we need to know exactly what is being done and what the efforts precisely are. There is fairly good documentation regarding the different behavioural interventions in Switzerland. It is less clear, however, what efforts are being undertaken with respect to building environments that are conducive and favourable for a healthy body weight and that support the programs targeting individuals by creating a supporting context. This is mainly due to the fact that the evidence regarding which environments are conducive and which are unfavourable for a healthy body weight has – to our knowledge – not been systematically collated and compiled. The insight gained from this literature will therefore facilitate the documentation of all weight-relevant actions being undertaken in Switzerland both by public health institutions as well as political, economic, sociocultural, technological, environmental and legal institutions.

The literature review will also reveal the potential for action if it is considered useful to shape the environment complementary to the rising number of behavioural interventions and clinical and pharmaceutical treatments.<sup>15</sup> This second-phase and policy-relevant aim of the literature review is to provide a basis for discussion and decision-making for experts as they evaluate the opportunities and threats that the future holds with respect to expected changes in the environment that may cause weight-relevant individual behaviour. The PESTEL framework will thus find its proper appli-

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<sup>15</sup> Policy interventions aiming at building environments that are health-conducive are sometimes called “upstream” interventions. They may complement or even alleviate the need for “upstream” behavioural interventions and “downstream” treatments such as clinical and pharmaceutical treatments.

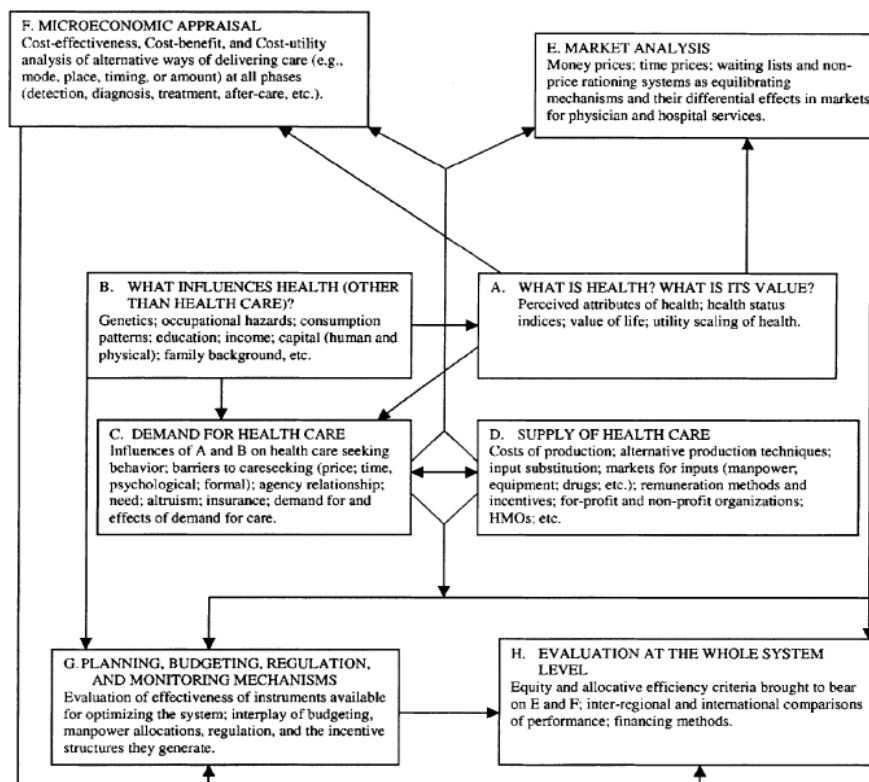
cation (as a tool to prepare for future opportunities and challenges) in this second phase where it helps to make decisions regarding actions necessary to either foster changes conducive to a healthy lifestyle or to avert threatening changes. This second-phase aim lies outside the scope of this work.

Lastly, over and above this, the systematic evidence search on the determinants of obesity will disclose the state of research in this field and point out gaps and challenges for future research with respect to the kind of indicators used and studied to assess specific attributes of the environment.

### 3.3 How this review fits into the context of health economics

As an orientation guide, how does this review fit into the context of health economics? The review question and the review's objectives are best illustrated with the help of the schematic of health economics as presented in the Handbook of Health Economics (Culyer and Newhouse 2000:4).

**Figure 3** A schematic of Health Economics



Source: Handbook of Health Economics (Culyer and Newhouse 2000:4).

The questions framing this review are to be allocated in the Box “B: What influences health (other than health care)?”, where we will take both a static and a dynamic perspective.

Evidence regarding the questions of Box “F: Microeconomic appraisal” with respect to efforts to prevent overweight and promote a healthy body weight has been collated

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and compiled systematically in the literature reviews by the WIG that were commissioned by Health Promotion Switzerland (Brügger et al. 2004; Eisenring et al. 2006; Federspiel et al. 2005; Schmidhauser and Brügger 2008).

The objectives of this review are (i) to gain insight on what influences health (Box B) and (ii) by piecing together the insight from Box B and the evidence from Box F to prepare the ground for the superordinate aim of this project, which is an economic appraisal of prevention and health promotion in comparison to treatment (Box H, whereas we are not aiming at an “evaluation at the whole system level” but rather at an “evaluation at a higher level”).

We will analyze from an economic perspective how and to what extent the micro-economic behavioural model can help explain the rising public health problems of overweight and obesity.

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## 4 Review methods

The review was undertaken in accordance with the Centre for Reviews and Dissemination (CRD) guidelines for undertaking systematic reviews (NHS Centre for Reviews and Dissemination 2001) in as far as the guidelines could be applied. Substantial deviations from the recommendations are explained.

### 4.1 Inclusion and exclusion criteria

In accordance with the recommendations from the NHS CRD Report (2001:phase 3) we defined the inclusion/exclusion criteria by breaking down the review question into the facets *population*, *exposure*, *outcomes* and *study design*. We further define criteria relating to the publication type, date, and language. See appendix I for tables summarizing the inclusion and exclusion criteria of the review at hand.

In order to define the limits of this review we will also explicitly itemize some aspects that this review will not address, and give pertinent reading suggestions instead (paragraph 4.2).

To ensure that the retrieved literature is relevant to the current increase observed in obesity prevalence we restricted the searches to the more current literature, i.e. with a publication date from 1980 onwards (as in similar reviews or recommended for example by Anderson et al. (2003b)). Therefore the studies searched were published between January 1980 and May 2008. Publication language was restricted to English, German, Spanish, Italian, and French. With respect to the type of publication we are interested in journal articles, reports, book sections and working papers. We explicitly include grey literature because a large part of the most recent findings (particularly in economics) are first available as working and discussion papers and would otherwise be overlooked. Reviews are not included as results but only used as a source for additional articles that may have been missed in the search. We exclude doctoral dissertations, editorials, comments, letter, case reports, interviews, news, guidelines, policy recommendations, and patient education handouts.

#### 4.1.1 Exposure

As derived above, we broadly define environment as ‘anything outside the individual’. We account for the political/legal, economic, sociocultural, technological, and physical/natural dimensions of the environment. These environment attributes can be either perceived (i.e. self-reported) or objectively determined (i.e. measured).

The environment being defined as ‘anything outside the individual’, we exclude studies examining the contribution of behavioural factors or preferences (effects of parental feeding practices and strategies, habits, attitudes, beliefs, perceived behavioural control, etc.) on the risk of becoming overweight. See Maffeis (2000) for a review on European research analyzing the influence of such factors on child and adolescent risk of obesity.

We also exclude studies analyzing how body weight (at different ages or stages) influences the probability for overweight or obesity at a later stage in life, or studies

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analyzing the biological or biochemical mechanisms of how the impact of certain food or beverage intake or of physical activity impacts on the person's weight. Likewise, we exclude studies analyzing associations between obesity and socio-demographic or physiological factors such as gender, age, race and ethnicity.

We exclude studies that primarily (or to a considerable degree) attempted to achieve behaviour change through education-based information dissemination about healthy living or healthy food choices. Most notably, school-based interventions modifying an environmental aspect (such as healthier food choices in cafeterias, or after-school sports courses) often are accompanied by education-based information dissemination to change students' knowledge and attitude. Since generally it is not possible (or not attempted) to disaggregate the specific effects of the changed food availability per se (i.e. the structural intervention), we do not include these studies in our review.

#### **4.1.2 Study population**

We will include studies analyzing the general population and also specific risk populations (e.g. with respect to ethnic, socioeconomic, and socio-demographic background). We will exclude studies analyzing specific population sub-groups consisting of patients (i.e. where "iatrogenic factors" and "biological factors" are more appropriate to explain individual risk of obesity).

We will exclude studies analyzing the newborn (defined as age birth to 1 month) and infants (defined as age 1 to 23 months). We also exclude studies on people of age 80 years and older. The rationale for this is that both age groups are very specific, with respect to nutrition, possibilities for physical activity, and possibly morbidity.

The studies included analyze data from industrialized, western countries (USA, Canada, Europe, Australia, New Zealand). Studies on populations from Africa, Asia, Greenland, Latin America and the South Pacific are excluded due to significant cultural (e.g. with respect to body images or overweight being a status symbol) and possibly biological differences which may confound the results. However, studies including data from individuals with a migration background from those geographic regions but with residence in the above listed industrialized, western countries are included.

#### **4.1.3 Outcome**

Studies have to present a measure of body weight status (overweight or obesity) as the outcome. There is no criterion with respect to how overweight or obesity is measured (i.e. whether it be the BMI, skinfold thickness, body fat percentage, or other); however, we expect the substantial part of the relevant literature to employ BMI as the most widespread indicator.

We will exclude studies reporting solely on weight-related indicators such as blood pressure, glycaemic index, etc. or physical activity and eating behaviour as the outcome measure.

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#### 4.1.4 Study design

We are interested in primary studies that report quantitative empirical results. We exclude studies with theoretical models only, studies with qualitative analyses only, reviews, and studies that are narrative in nature only or do not make a quantitative estimation of an association.

Regarding the quantitative analyses we include both observational (cross-sectional studies, cohort studies, case-control studies) and experimental studies ((randomized) controlled trials).

#### 4.2 Economic aspects of obesity this review does not address

Please note that this review will **not** cover the following economic aspects of obesity:

- How much should individuals rationally invest in health in absolute terms, and to what extent can a micro-economic perspective suggest a different level of health capital than the medical perspective? This has been examined elsewhere. Specifically, Becker (1964/1993) and Grossman (1972; 2000) have contributed invaluablely to the understanding of the economics of health capital.
- Is the theory of rational choice applicable to obesity, i.e. is it rational or irrational if people are too heavy, eat too much, exercise too little, etc.? Do individuals exhibit consistent time preference rates and value both immediate consumption and future health appropriately, and do they dispose of self-control (Smith 2002). Becker and Murphy (1988) and Levy (2002) provide insight in the possible micro-economic rationality of overweight, addiction, and health-damaging behaviour in general. In this review we assume that individuals are rational (and exhibit consistent time preferences) and examine what kind of behaviour (i.e. choices) this produces. However, the assumption of rationality (and consumer sovereignty in general) is not even necessary because the incentive effects of the environment and alignments thereof work regardless whether or not people are fully rational. Nevertheless, this discussion is interesting in as far as it deliberates on the question whether there is an (economic) justification for public policies; see e.g. Cawley (2004:120-3) and Anderson (2003b:31-2).
- Are individuals fully (or sufficiently) informed in order to make rational decisions? The value of health literacy and the problems arising from a lack thereof are presented by Eichler et al. (2008). In this review we assume problem awareness and health literacy among individuals.
- What are the economic consequences of obesity? What are the costs for the health care system, for society, and for the patient, also in terms of labour market outcomes? The economic burden of obesity has been reviewed (Caterson et al. 2004; Eisenring et al. 2006; Federspiel et al. 2005; Schmidhauser and Brügger 2008) and estimated specifically for Switzerland (Schneider and Schmid 2004) elsewhere.

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- Are individual behaviour-based interventions such as lifestyle interventions and clinical or pharmacological treatments cost effective? Economic evaluations of such interventions have been reviewed e.g. by the WIG (Eisenring et al. 2006; Federspiel et al. 2005; Schmidhauser and Brügger 2008).

### 4.3 Search process

The final search strategy was developed by an iterative process to identify the combination of terms that seemed most sensitive in identifying relevant studies. The sensitivity of our search strategy (a measure of the comprehensiveness of a search method, i.e. its ability to identify all relevant articles on a given topic) was continuously examined by checking whether key literature from our personal databases that should be selected through the search strategy was actually retrieved.

### 4.4 Data sources and search strategies

We conducted computerized searches of electronic databases and handsearches.

The computerized searches were conducted for the following electronic **medical databases**: Medline, EMBASE, Cochrane Library, PsycINFO, and Psycindex Plus. We involved an information expert from the Medical Library Careum at the University of Zurich in the development and execution of the search of the electronic medical databases. See appendix II for a detailed description of the search terms.

The following electronic **economics** and **social sciences databases** were searched by hand to complement the search in the medical databases: Social Science Research Network SSRN, National Bureau of Economic Research NBER Working Papers database, ECONIS, wiso Wirtschafts- und Sozialwissenschaften, EconPapers, and IDEAS RePec. We searched these databases (with a far less extensive literature relating to weight) for the words “obesity”, “overweight”, “BMI”, and “body mass index”.

We scanned the **reference lists of publications** found through database searches to identify further studies for consideration. Those primary studies included in identified systematic reviews which meet inclusion criteria were included individually in the review.

This search in electronic databases was accompanied by **handsearching the internet** using Google Scholar and scanning through the first 200 hits in response to the terms “obesity”, “overweight”, “BMI”, and “body mass index”. Moreover, we searched the internet sites of two major international organisations fighting obesity, the World Health Organization WHO and the International Obesity Task Force IOTF, for relevant reports. Important results may have been published in reports, discussion papers or other formats which are not indexed in the major databases. Research in progress can best be acquired through conference proceedings. Moreover, the internet may be a useful source of information about conference proceedings, grey literature, very recent publications which have yet to be cited by other publications or included on the electronic databases, and ongoing research.

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Moreover, through contacts to **subject experts** information on any ongoing research that could be considered for inclusion in the review was provided.

#### **4.5 Study quality assessment**

It is important to account for the study quality to assess the internal and external validity of the findings. The study quality assessment employed in this review consists of 9 checklist items which are based on items 8-12 of the STROBE statement. The study quality checklist is included below in Appendix III.

External validity was assessed by checking for the study population characteristics and for the recruitment of the population and/or data sources. In addition, the variability of the results according to the sensitivity analysis was assessed to get an indication of the uncertainty of the results.

Internal validity was assessed by whether there is an unambiguous definition of the outcome indicator and determinants, and of their measurement method, whether there was sufficient completeness of follow-up, and whether adequate analysis techniques were used (with respect to missing data, measures of uncertainty, confounding).

The scoring of the quality checklist items is 'No/Yes/Unclear'. For example, a study that does not fulfil 2 items, fulfils 6 items, and remains unclear about 1 item is assigned the score 2/6/1. If an item (or several items) is not applicable to a study (e.g. item 5 if study is not a cohort study), the score will add up to less than 9. Thus, a quality aspect is that all the relevant information required for the data extraction is presented. If substantial information is missing then we cannot draw meaningful conclusions with respect to the validity of the findings and we cannot compare the findings with similar studies as the table is structured to contain the important aspects that could explain a variation in effects.

The results of the quality assessment will be used for several purposes: First, it will be used to determine the strength of inference and as a possible explanation for heterogeneity in effects when interpreting the results. Second, study quality will be used for descriptive purposes to provide an evaluation of the overall quality of the included studies and make recommendations for the design of future research.

Study quality is not used to establish a quality threshold for inclusion in our review. We will report specific information on quality features in the data extraction form.

#### **4.6 Study selection and data extraction**

The study selection and the data extraction were undertaken by one reviewer.

From each relevant study, the following information will be extracted and tabulated:

- Study reference
- Outcome indicator
- Determinants analyzed: environment domain, type of measure



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- Population: data source, sample (recruitment if applicable), sample size, time frame, and country
  - Study quality assessment scores
  - Relationship of determinant to outcome: quantity and direction of the effect; relationships are quantified in examples
  - Notes

The aims of the data compilation are to describe the studies to allow an assessment of (i) whether the effect of the treatment is large enough to be regarded as obvious, and if the effects are consistent across the studies, (ii) of whether participants, interventions, and outcomes in the studies allow the generalisation of the results, (iii) of whether the quality of the studies is adequate to trust their results. Thus, the table is structured to contain the important aspects that could produce and explain a variation in effects. Moreover, the data compilation is to highlight the absence of data for planned comparisons (NHS Centre for Review and Dissemination 2001).

With regard to the data sources used in the studies, they are important information to avoid including multiple publications based on the same data. It is important to identify serial publications where papers report accumulating numbers of participants or increasing length of follow up because during data synthesis it would be misleading to include the results of several reports of the same study (so-called 'multiple publication bias'). Likewise, in studies that report results from different statistical techniques and model specifications, only the main results are reported.

## **4.7 Result synthesis**

Based on the data extraction we will synthesize the review results in two ways: we will provide a narrative, descriptive result synthesis and a table or 'thematic map' to allow a quick overview. The thematic map is based on a matrix that reflects the dissection of the environment into the domains of environment (political/legal, economic, sociocultural, technological, physical/natural and policy domain) and the size of environment (micro, meso, macro). The categorization of the environmental attributes into one of the 'boxes' in this matrix was done logically; however, as with many attempts to dissect a complex, interlinked system into categories, there are always ambiguities. The purpose of the matrix is threefold: first, it serves as a map to organize the complexity of the many aspects in our environment that influence the risk of overweight and to synthesize the findings. Second, it serves as a summary to illustrate in what 'box' of the matrix research has been most active, and where there might be a need for more research. Third, it serves as a tool for policy recommendation (see chapter 7).

The information collected in the data extraction sheets thus will form the succinct basis on which the assessment of the evidence, the state of research, and the discussion on the heterogeneity of observed effects will be based.

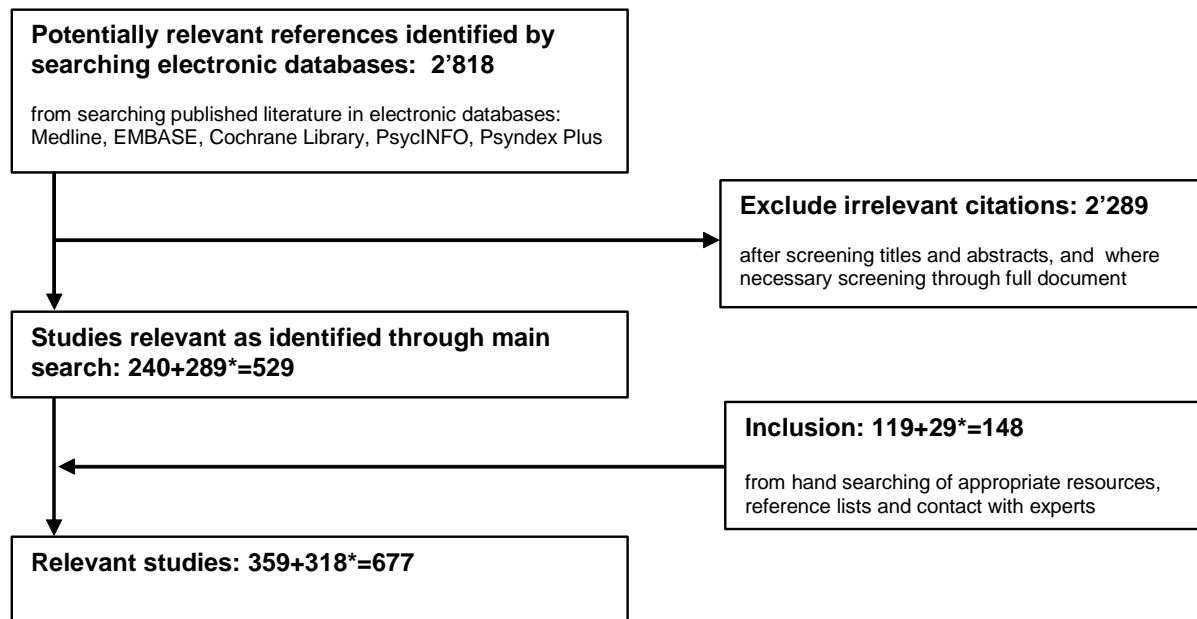
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## 5 Results

### 5.1 Studies found through the search

The details of the study selection process are reported in the following flowchart.

**Figure 4** Flowchart describing process of identifying relevant literature



The numbers labelled with \* are studies exclusively analyzing the association between overweight/obesity and some measure of socioeconomic status SES.

The high number of studies retrieved in our initial search surprised us. Our search strategy was intended to be sensitive. Nevertheless, judging from numerous research recommendation articles and editorials we expected a substantially smaller number of studies relating both to overweight/obesity and environment. In the process of screening through the 2'818 references we had to exclude the majority of studies (=2'289).<sup>16</sup> The reason for exclusion was mainly one of two following: either outcome was not a measure of overweight or obesity but of a related behaviour (e.g. physical activity, sedentary behaviour, eating patterns), or the concept of environment employed in the study did not correspond to the concept of environment this review is based on. In particular, many studies examined the association of overweight and obesity prevalence to socio-demographic characteristics such as age, gender, ethnicity, critical periods in life, etc. Further, an entire strand of studies had to be excluded

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<sup>16</sup> In their recently published review, Black and Macinko (Black and Macinko 2008) report that they found 2'000 potential articles in their search for neighbourhood determinants of obesity. Out of these 2'000 studies, only 90 actually assessed neighbourhood determinants of obesity, and of those only 36 studies included a specific measure of body weight status or obesity. Thus, the high number of studies retrieved in the search is by no means unusual. The differences between the review by Black and Macinko and the review at hand primarily relate to the environment concept (restricted to the neighbourhood in Black and Macinko's review), the search sources, and the time of the search.

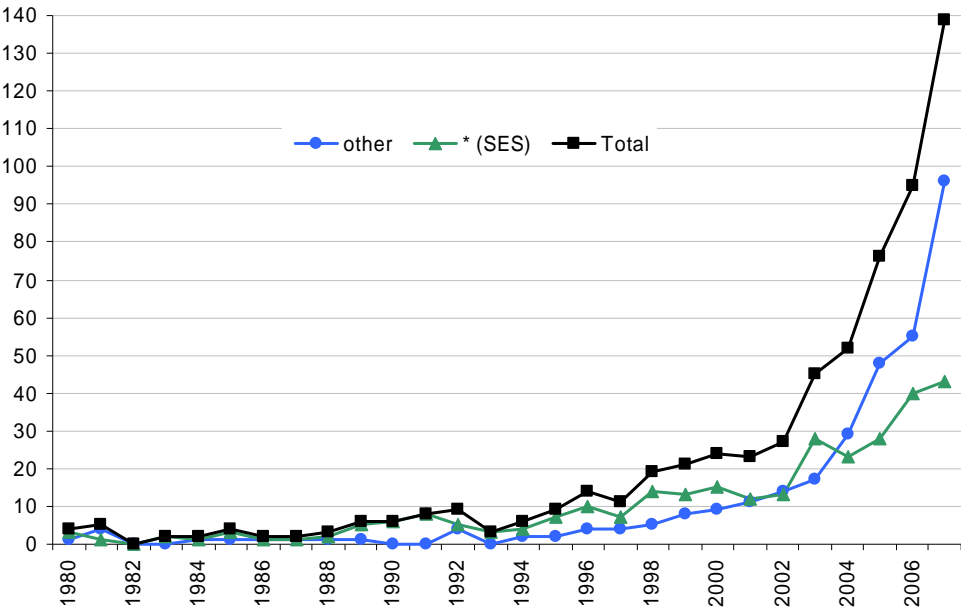
because they examined the consequences of overweight or obesity on socioeconomic outcome of the individual. We hardly had to exclude studies for reasons that they related to a time before 1980 (in total, 27 studies; however, they did not correspond to the review question in any case).

The number of studies is substantial despite the fact that a large share of the references from the initial search had to be excluded because they did not relate to the review question. In particular, studies examining the association between overweight/obesity and some measure of SES make a fair contribution to this large number by accounting for nearly half of the relevant studies. We differentiate between studies relating to the SES only and all other studies (where many include some socioeconomic indicator as a control variable).

The hand search, which expanded the search to electronic databases of economic and social sciences and other appropriate resources, was successful. Nearly 30% of all studies (and nearly 50% of all studies when we exclude the studies examining associations of the SES) were retrieved from the hand search. This resulted in a final sample of 359 key references and 318 additional references relating solely to associations of the SES. The high proportion of studies retrieved from the hand search does not imply that the initial search was unsound. Instead, it demonstrates that the problem of overweight/obesity is no longer seen as just a medical issue but that it has strongly expanded into fields of other sciences. It seems to be widely accepted today that resolving the current overweight/obesity epidemic requires an interdisciplinary approach. This search shows that this understanding has established itself in the scientific community.

Regarding the time trend of research in this field being published per year, there is a clear increase in the number of studies in recent years. The following diagram depicts the development.

**Figure 5** Number of publications by year (1980-2007)



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While the number of studies regarding the association with the SES has been rising more steadily, even slowing down, the research on the association with all other environment concepts has risen exponentially in the past few years.<sup>17</sup>

## 5.2 Thematic map

The large number of 677 studies in total in the final sample made it clearly impossible to systematically extract information from the studies, assess their quality and conduct advanced analyses. A different approach was required. We proceeded by constructing a thematic map of all the studies (see Table 1). The aim was to identify the fields in which research is very active and productive, and in which it is not.

This requires the identification of the environmental factors used in each study's analyses. This task is still difficult to manage for the number of 677 studies. The problem is that the abstract, which is easily available and relatively quickly studied, often does not contain "the whole truth" of the analysis. Most often, the abstract is too concise to hold information on all the factors that were studied. Consequently, only the most relevant or most interesting factors are itemized in the abstract. Also, abstracts are sometimes not precise enough to allow the reader to judge whether a particular indicator was in fact used. For example, an abstract might discuss the effects of a factor on obesity, while in fact, the outcome used is not obesity but sedentary behaviour, eating or purchasing patterns, etc.

Despite these sources of error, we largely relied on the abstracts of the 677 studies to construct the thematic map because screening through the full documents was not feasible for reasons of limited time and budget. In light of the potential fallibility of the procedure, we conducted tests among a random sub-sample of the 677 studies to certify that the information from the abstract corresponded to the studies' content. Moreover, if the abstract was too vague, we also inquired in the full document. Nevertheless, we can not guarantee that the thematic map constructed here does not suffer from some incompleteness or inaccuracy. For these same reasons, we cannot guarantee that a study, which has been published more than once with the same (or largely the same) content, is only included once. We excluded earlier versions of an article (e.g. the working paper version) if it was obvious from the title, abstract, and authorship that it was the same study. If there were any differences, however, we included both. (See the next chapter for a discussion on possible biases).

The results of the thematic mapping are illustrated in table 1. The thematic map differentiates between the 5 environments according to PESTEL, with an additional column for studies evaluating policy measures that are relevant to the field. Further, the table makes a distinction between the macro-level, the meso-level, and the micro-level, in accordance with the concept of multilevel analyses or ecological models (see e.g. Diez-Roux 2000). The macro-level stands for variables that are measured on the

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<sup>17</sup> We did not include the studies published in 2008 in the diagram as the literature search was conducted in May 2008, and the number of studies published by May in any year is not a representative figure for the year.

**Table 1** Thematic map

	Politics & Law	Economics	Society and culture
Macro (society)	<ul style="list-style-type: none"> <li>• Governance (1)</li> <li>• Civil law origin (1)</li> </ul>	<p><u>Economic cycle, growth</u></p> <ul style="list-style-type: none"> <li>• Gross domestic product GDP (11)</li> <li>• Income per capita (3)</li> <li>• Employment / unemployment rate (4)</li> </ul> <p><u>Inequality</u></p> <ul style="list-style-type: none"> <li>• Income inequality (10)</li> <li>• % educational attainment (2)</li> <li>• food stamp eligibility/ participation rate (1)</li> </ul> <p><u>Free market forces</u></p> <ul style="list-style-type: none"> <li>• Unregulated market forces (2)</li> <li>• Transition to market economy (10)</li> </ul> <p><u>Prices</u></p> <ul style="list-style-type: none"> <li>• Food prices (13)</li> <li>• Gasoline prices (3)</li> </ul>	<ul style="list-style-type: none"> <li>• Female labour force participation (5)</li> <li>• Maternal employment (23)</li> <li>• Parental non-standard work schedules (3)</li> <li>• Parent being home when child comes home from school (1)</li> <li>• Meal source: food away from home (14)</li> </ul>
Meso (organization and neighbourhood)	<i>not relevant</i>	<ul style="list-style-type: none"> <li>• Area-level socio-economic deprivation (40)</li> </ul>	<ul style="list-style-type: none"> <li>• Neighbourhood social cohesion, support, and network (11)</li> <li>• Civic participation, club membership (6)</li> </ul>
Micro (family and friends)	<i>not relevant</i>	<ul style="list-style-type: none"> <li>• Socio-economic status: <ul style="list-style-type: none"> <li>- Studies (318+)</li> <li>- Reviews (8)</li> </ul> </li> <li>• Time constraints (1)</li> <li>• Employment status and overtime work as a proxy for time constraints (39)</li> <li>• Rate of time discounting (3)</li> </ul>	<p><u>Other people's body weight</u></p> <ul style="list-style-type: none"> <li>• Body weight of family members (46)</li> <li>• Partner's body weight (2)</li> <li>• Peers' body weight (6)</li> <li>• Body weight image (3)</li> </ul> <p><u>Family rules</u></p> <ul style="list-style-type: none"> <li>• Breakfast eating (11)</li> <li>• Snacking (3)</li> <li>• Meals while watching TV (3)</li> <li>• Frequency of family meals (3)</li> <li>• Parent in room while eating dinner (1)</li> <li>• Parental control over intake (3)</li> <li>• Parent engaging in physical activity with child (3)</li> </ul>

**Table 1** Thematic map, continued

	<b>Technology</b>	<b>Physical and natural environment</b>	<b>Policy measures</b>
<b>Macro-level (society)</b>	<p><u>Technology &amp; physical activity</u></p> <ul style="list-style-type: none"> <li>Physical strenuousness of job (13)</li> <li>Transport-related physical activity (18)</li> </ul> <p><u>Technology &amp; leisure-time</u></p> <ul style="list-style-type: none"> <li>Availability of sedentary leisure options (TV, etc.) (5)</li> <li>Review TV viewing / screen time (5)</li> <li>IT revolution (2)</li> </ul> <p><u>Technology &amp; food</u></p> <ul style="list-style-type: none"> <li>Agricultural output / productivity (3)</li> <li>Processed food (5)</li> <li>Meal size (1)</li> <li>Food advertising (5)</li> </ul> <p><u>Technology &amp; stress</u></p> <ul style="list-style-type: none"> <li>Stress-level (7)</li> </ul>	<ul style="list-style-type: none"> <li>Degree of urbanization (5)</li> <li>Population density (9)</li> <li>Rural / urban residence (44)</li> <li>Climate, season, temperatures (6)</li> </ul>	<ul style="list-style-type: none"> <li>PE requirement law (1)</li> <li>Smoking policy (5)</li> <li>Education policy (2)</li> <li>Environment policy (2)</li> <li>Food market regulations (7)</li> </ul>
<b>Meso-level (organization and neighbourhood)</b>	<i>not relevant</i>	<p><u>Neighbourhood environment</u></p> <ul style="list-style-type: none"> <li>Availability / proximity / density of <ul style="list-style-type: none"> <li>Restaurants (10)</li> <li>Fast food outlets (16)</li> <li>Grocery stores (10)</li> </ul> </li> <li>Neighbourhood PA environment (51)</li> </ul> <p><u>School environment</u></p> <ul style="list-style-type: none"> <li>School cafeteria food (8)</li> <li>School food practices (outside cafeteria) (5)</li> <li>School PE time (5)</li> <li>Availability of structured after-school activities (2)</li> <li>Outdoor play / gym equipment (1)</li> <li>Type of kindergarten / day care (2)</li> </ul>	<ul style="list-style-type: none"> <li>Worksite intervention (2)</li> <li>Sports programme interventions (4)</li> <li>School food and sports intervention (1)</li> <li>Home, school and community intervention (1)</li> </ul>
<b>Micro-level (family and friends)</b>	<i>not relevant</i>		<ul style="list-style-type: none"> <li>Minimum wage law (1)</li> <li>Income support (1)</li> <li>Public housing assistance (2)</li> <li>School food programme (6)</li> <li>Food assistance programme (15)</li> </ul>

Number of studies found per topic is in parentheses. Some studies touch on several topics; the sum of the numbers in parentheses therefore exceeds the total number of studies found.

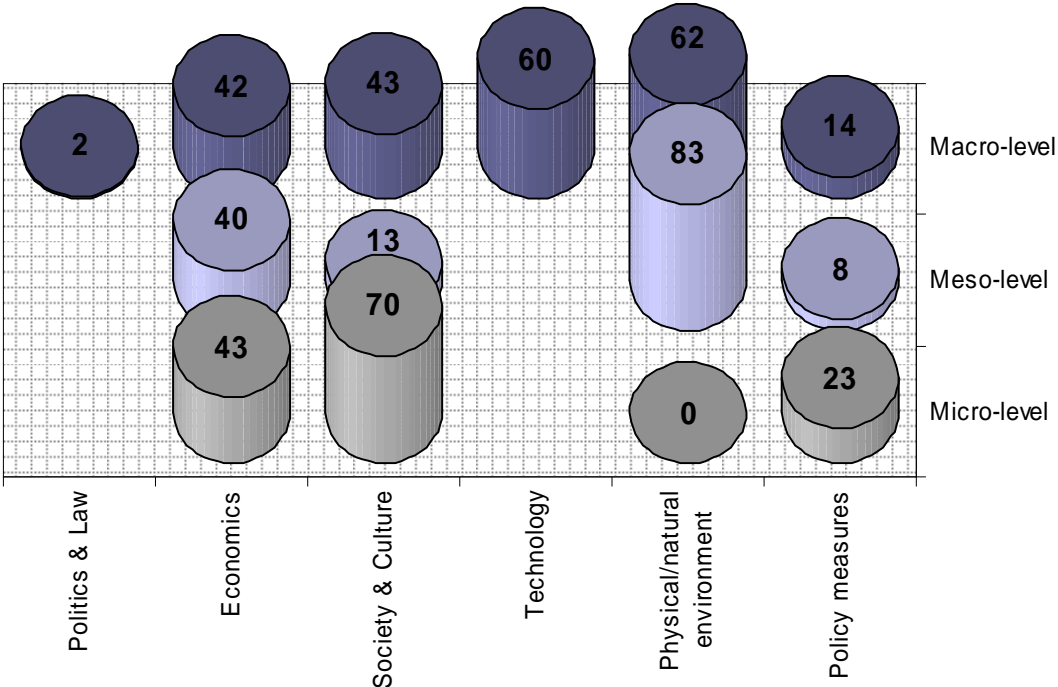
The respective detailed references are listed in the tables in the appendix IV.

level of the society or a country. The meso-level contains variables that are measured on the level of the community, neighbourhood, school or work environment. The micro-level environment is the environment composed by family and peers.

The micro-level and the meso-level are not relevant to the political/legal environment and to the technological environment since law and technology only really happen on the macro-level. Therefore, those fields are left empty. The boxes contain the different strands of analysis along with the respective number of studies found (in parentheses).

The respective detailed references are listed in the tables in the appendix IV. For the purpose of clarity, the following diagram illustrates how the number of studies is distributed across the thematic map, not differentiating between the single strands of literature.

**Figure 6** Number of publications by box on the thematic map



The 318+ studies on the association between SES only and overweight/obesity are not included in this diagram, nor are the 8 reviews on the subject. The 43 studies found on the micro-level of the economic environment would be much higher if they were included.

Some studies touch on several topics; the sum of the numbers in parentheses therefore exceeds the total number of studies found.

Research has been active in all six domains of the environment, with most fields covered well. The intensity of research carried out in the different fields is quite variable. Partly, the degree of variability depends on the classification system. For ex-

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ample, some variables that we attributed to technology (e.g. meal size) might also be assigned to the domain of economics. Also, the classification into the macro-, meso- and micro-level is not always straightforward. Every classification scheme that aims at reducing a complex world will be subject to ambiguity and controversy.

At first, it seems odd that only 2 studies were conducted in the field relating to the political/legal environment. This is plausible, though, as it is quite hard to think of a hypothesis relating the political/legal system to overweight/obesity.

Further, it is striking that there are no studies relating to the micro-level physical/natural environment. We would have expected some studies examining whether the home food environment influences overweight/obesity in particular among children, as the home food environment defines what is immediately available or not available to children. In our search we came across studies examining the association between the home food environment (e.g. availability of fruits and vegetables, availability of snacks) and the eating behaviour, not overweight/obesity though.

The large number of studies found relating to the micro-level of the sociocultural environment (70) is also eye-catching. However, the majority of these 70 studies are studies examining the association between parents' body weight and children's body weight. This association is likely to be largely genetically driven. However, it is an important strand of literature as a positive association may also hint at the impact of the shared environment (home food environment, physical/natural neighbourhood environment, and SES).

Most fields are surprisingly well covered. The 83 references relating to the meso-level of the physical/natural environment are particularly remarkable as the first references in this field were published only in 2002.

It is interesting that we found no studies analyzing the association between the work environment and overweight while a good number of studies examined the impact of the school environment. This may mirror the general view that adults have more alternatives, whereas children are bound to the options offered at school. Therefore, the school may exert a much stronger influence on children than the work environment would on adults. Nevertheless, we found one article describing the interventions and study designs of 7 separate worksite interventions including environmental-level strategies to reduce BMI that are currently being undertaken but have not been evaluated yet (Pratt et al. 2007).

In the following we will provide background information on the different fields on the thematic map, such as potential hypotheses or underlying theories. The corresponding literature references are listed separately for every field in the appendix.

Whenever possible we will differentiate between the environment factor's association with overweight/obesity via either energy intake and energy expenditure. Energy intake is influenced by what we eat, by how often we eat, and by how much we eat each time we eat something. All these consumption choices depend on the 4 Ps, following Jerome McCarthy (1960), namely *product* (taste, healthfulness, variety, convenience, etc. of food choices), *price* (includes the time cost of preparing it), *place*



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(proximity, access, availability of food choices), and *promotion* (advertising of food choices) (McCarthy 1960).

Energy expenditure, on the other hand, is the overall sum of *leisure-time physical activity* (i.e. how intensively and how often we undertake physical activity during leisure time), *occupational physical activity* (i.e. job strenuousness), *household-related physical activity* (strenuousness of the activities of daily living), and *transport-related physical activity* (active versus passive transportation modes) (WHO 2000:113).

### 5.2.1 Political and legal environment

Relating to the association between overweight/obesity and the political/legal environment, we found only two studies. They examine the association with the civil law origin and on a set of governance quality indicators.<sup>18</sup>

With regard to the quality of governance, it is hypothesized that better stability and higher effectiveness of a government may provide a better opportunity for policy makers to focus on key public health problems such as obesity, which should lead to lower obesity rates (Rabin et al. 2007:59). However, the authors themselves qualify that the theoretical underpinnings are not very clear.

With regard to the civil law origin, the link to obesity seems more straightforward. The civil law origin is assumed to capture the overall prevalence of regulations in a country. The authors of the study linking civil law origin with overweight find empirical evidence that countries with a common law legal origin (the British model) are much less regulated than are countries with a civil law origin (the French model) (Cutler et al. 2003:111). The degree of regulation, in particular of the market forces, may exert an influence on body weight status through restricted market entry, food statutes, lack of pricing freedom, and producer (subventions) or consumer protections, etc. The association of market regulation with obesity is discussed more in-depth below in the paragraph on the macro-level economic environment.

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<sup>18</sup> The indicators relate to (i) 'voice and accountability' (extent to which citizens of a country are able to participate in the selection of governments and the independence of media), (ii) 'political stability' (perceptions of the likelihood that the government in power will be destabilized or overthrown), (iii) 'government effectiveness' (quality of 'inputs' (e.g. bureaucracy, public service provision, etc.) required for the government to be able to produce and implement good policies and deliver public goods), (iv) 'regulatory quality' (measures of the incidence of market unfriendly policies and perceptions of the burdens imposed by excessive regulation in areas such as foreign trade and business development), (v) 'rule of law' (success of a society in developing an environment in which fair and predictable rules form the basis for economic and social interactions, and the extent to which property rights are protected), and (vi) 'control of corruption' (perceptions of corruption, conventionally defined as the exercise of public power for private gain). These six indicators are also combined to form an average governance indicator (calculated as the arithmetic mean of the six average indicators for each country).

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## 5.2.2 Economic environment

### 5.2.2.1 Macro-economic environment

At the macro-level of the economic environment, a number of factors have been examined concerning their relationship to obesity. Indicators used relate to

- (a) Economic cycle and growth
- (b) Income inequality
- (c) Transition to a free market economy
- (c) (Relative) prices.

#### a) Economic cycle and growth

Worldwide comparisons show that obesity rates increase with income per capita. This is mainly driven by the discrepancies in income and the overweight prevalence in developing and developed countries and does not relate to the income gradient within developed countries which is well known to be reverse.

The worldwide positive association between income per capita and obesity rates may reflect the advances of technology. Technological progress has two effects: First, it aims at increasing convenience by substituting manual labour by machines, active transportation by faster, more comfortable forms of transport, and natural, home-cooked food by readily available, convenient mass-produced foods and drinks (Branca et al. 2007:11). Second, technology increases the productivity of human labour and thereby wages. Thus, as national incomes increase, physical activity (all but leisure-time) decreases and the availability of pre-prepared foods and the affordability of all foods increase. If food is a normal good (i.e. its consumption rises with increasing incomes), economic growth thus boosts food consumption. Furthermore, rising incomes may affect individuals' decisions of time-allocation in two different ways: The first channel is that rising incomes make people's time more expensive, thus increasing the opportunity cost of physical activity and home-cooking (substitution effect). In response to this, people would be expected to exercise less and eat out more or consume more pre-prepared foods. The second channel is that rising incomes increase people's purchasing power so that essentially people are equally well off with less time spent working (income effect). In response to this income effect, people would have more time for physical activity and cooking fresh meals.

The fact that obesity rates increase with income per capita worldwide seems to stand in contrast to the fact that obesity is more common among socioeconomically disadvantaged groups (see paragraph on the micro-economic environment below). However, obesity seems to be linked to economic deprivation only within high-income countries, i.e. on a micro-level. An explanation for this is that after a certain income-level (and degree of food security or satiation) has been reached, people start to distinguish between foods. Instead of all food being a normal good, high-income societies begin to consider high-quality, fresh food as normal (or even superior) goods while pre-prepared, energy-dense food becomes inferior (its consumption decreasing

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with rising incomes). Unfortunately, to our knowledge this hypothesis has so far remained untested.

This hypothesis would imply that within high-income countries, the obesity problem may abate with increases in real income for all population groups. However, with real incomes rising also in developing countries, the obesity problem would simply relocate.

## **b) Income inequality**

It has been proposed that income inequality is detrimental to the health of residents because it leads to a disinvestment in human capital and public services, an erosion of social capital or social cohesion, and to a sense of relative deprivation (Chang and Christakis 2005:84).

With respect to income inequality leading to a disinvestment in human capital and public services in general it is hypothesised that with increasing income inequality the interests of the rich begin to diverge from those of the typical family. This engenders a demand for lower taxes and public services among the elite who have greater political clout or influence.

With respect to income inequality eroding social capital and social cohesion it is argued that income inequality leads to areas with lower social capital due to a lack of social intermix. This puts persons at risk for overweight because they lack appropriate health information and affective supports, etc. However, it should be noted that this hypothesis is limited to the extent that social capital has been shown to have both positive and negative associations to socioeconomic attainments.

With respect to income inequality evoking a sense of relative deprivation in the population, this may be explained by a relatively low real income. Assuming, as above, that in high-income countries healthy quality food is a normal or superior good whereas pre-prepared, energy-dense food is inferior, income inequality may in fact cause overweight among the low-income share of the population. The larger the income gap in a society the more prone low-income individuals are to buying inferior food which causes obesity.

Generally speaking, income inequality is hypothesised to be detrimental to health because income inequality entails poverty. As such, income inequality as a macro-economic indicator is essentially the same as the SES as a micro- or meso-economic indicator (see below for more information on those determinants). The question is merely whether it is income in absolute terms or in relative terms (i.e. inequality) that may cause obesity. While some state that poverty is necessarily a relative and not an absolute concept,<sup>19</sup> others criticize that the effect of income inequality on overweight

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<sup>19</sup> In his book, Fuchs (1998) broaches the issue whether poverty in terms of income should be defined according to some fixed standard (absolute income) or according to position in the income distribution (relative income). He claims that if we cling to fixed standards (absolute levels), economic growth gradually raises almost everyone out of poverty so defined but the problems we usually associate with poverty persist. So-called subsistence budgets are adjusted to new social norms. Alternatively, to define poverty in terms of the bottom 10 or 20 percent of the income distribution does not help us get to

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is confounded by individual incomes, or the simultaneousness of income inequality, educational attainment and a physical/natural environment and environment, and that income inequality is really just a proxy for these determinant factors.

**c) Transition to free market forces**

The indicators used primarily to measure the degree of market freedom in the studies found related to pricing freedom and market entry ease (measured by price controls, producer protection, subsidies, taxes, food laws, etc.). A free market economy may be associated with overweight by providing both incentives and disincentives for eating as it affects the prices, products, availability (place) and promotion of goods.

Pricing freedom is the ability of businesses to set their own prices. Through regulations, prices may be kept either higher or lower than worldwide prices through subsidies, price controls, and taxes. Relatively high prices will most likely lead to lower consumption, while relatively low prices will encourage consumption. Overall, countries with a higher pricing freedom are expected to have lower prices, higher caloric intake and thus higher overweight rates. Countries with a greater degree of regulation in the agricultural or consumption sector are expected to have higher prices and consequently lower overweight rates (Cutler et al. 2003).

Higher pricing freedom may also encourage innovation as there is more potential for businesses to make profits. Innovation, along with market entry ease (e.g. short time to open a new business and a low number of food laws, packaging and labelling requirements), is likely to increase the availability and accessibility of food, which may be associated with overweight.

For studying the impact of these market forces on the body weight status, the quasi-experiment of the transition of Eastern European countries to market economies after the collapse of communism might be very valuable. It is hypothesized that obesity prevalence is higher in the nations experiencing the most significant global influences by having entered the European Union (Czech Republic, Slovakia, Hungary and Poland) than in those remaining tied economically and politically to Russia (Ukraine, Belarus and Moldova) (see e.g. Rabin et al. (2007:56)). This difference is due to the transition in the economic environments, but also to sociocultural changes and technological progress associated with the global information diffusion once this became possible. This globalization, urbanization and westernization occurred relatively fast, providing little time for individuals to readapt to the new circumstances, incentives and disincentives. Thus, it could be argued, that the faster the changes occur in our environment, the less time we have to adapt to the new circumstances to accommodate the new conveniences and possibilities with the aim of staying healthy.

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the heart of the problem either. In a society with little inequality of income, being at the lower end need not have the same negative implications as when the distribution is very unequal. Thus: people usually think of themselves (and are regarded) as poor when their command over material resources is much less than others. Poverty as an economic concept is largely a matter of economic distance. For these reasons, in 1965, Fuchs proposed a poverty threshold of one-half of median income. "There is considerable resistance to such a definition because a reduction in poverty so defined requires a change in the distribution of income – always a difficult task for political economy" (Fuchs 1998:166).

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**d) Prices (food, gasoline)**

As has become obvious so far, a myriad of factors may have impacted the price of food consumption and of energy expenditure in the last decades, relating to the market forces, to regulations such as agricultural policies, to technological innovation and its impact on productivity and on wages, etc.

Relating to energy intake, there are two elements contributing to the total costs in the short term: the product price and the time and/or travel cost of preparing the food or obtaining it away from home. Innovations in agriculture or in the food industry decrease the product price. An increase in wages or employment increases the opportunity costs of time. The travel costs, as a part of grocery shopping or of food-away-from-home consumption, depend on the proximity of such facilities to the home (i.e. the physical/natural environment). Generally speaking, lower overall prices encourage the consumption of the good under question. Apart from an effect on the quantity consumed of the goods under question, there may also be an impact on the consumption of other goods, namely of substitutes or complements. For example, the consumption of energy-dense food away-from-home is often complemented with soft drinks. Philipson and Posner (2003), Liu et al. (2007), Milijkovic and Nganje (2008) propose theoretical economic models to explain the impact of prices on body weight status.

Regarding the product price, there has been a reduction in the relative price of energy-dense, processed foods compared to fresh produce. The relative inexpensiveness of fast food, convenience food, and other energy-dense food in terms of product price per calorie and in time costs is often said to be related to a substantial increase in the consumption of these foods (Drewnowski 2004; Drewnowski 2007; Drewnowski and Darmon 2005; Drewnowski and Specter 2004). "The lower relative price of energy-dense foods results from the fact that added sugars and fats are easier to produce, process, transport, and store than are perishable meats, dairy products or fresh produce" (Drewnowski 2004:156). In addition, agricultural policies artificially lower the prices of subsidized goods. Corn, for example, is subsidized in the US, and corn syrup can thus be used as a cheap input to sweeten soft drinks (Morrill and Chinn 2004:361). The subsidy of one good can thus lower the price of a good that is produced with it.

Changes in the product price can be related to changes in the fixed costs of the production, of the variable costs, or of both. The fixed costs of the production allegedly decreased with technological innovations both at home (e.g. microwave) and in the food industry (e.g. machines or processes). The variable costs of the production are mainly the groceries. Cutler et al. (2003) examine the implications that a decrease in the fixed costs relative to the variable costs would have. If fixed costs decrease more than variable costs, it is expected that the consumption of mass-prepared food increased more than consumption of food in general.

Regarding the time costs, technological progress and economic growth have increased wages. In particular, time costs have risen for women because of their increasing educational attainment and labour force participation rate. At the same time that the time costs have risen (probably in response to an according demand in soci-

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ety), technological change has reduced the time required to prepare some foods: innovations in food processing, preservation, and packaging made it possible for food to be mass prepared far from the place of consumption and to be consumed with less time cost. “Time-saving devices, including drivethrough, 24-h, take-away and home delivery food services have helped to make food ubiquitous in everyday life in the United States, and increasingly elsewhere” (Ulijaszek 2007:448). These innovations may have contributed to a shift away from home-cooked meals toward processed food. How processed food may be related to obesity is discussed in field 4. As a consequence of increases in time costs, it would be expected that those groups in the population that have had greatest ability to take advantage of the drop in the time of food preparation have gained most weight (Cutler et al. 2003).

While the substitution effect of rising incomes and price decreases is very often discussed and brought forth as a reason for increasing obesity rates, the income effect is hardly ever addressed. However, from an economic point of view, the income effect may be equally relevant as the substitution effect. According to the income effect, rising incomes (because of rising wages or decreasing prices) may in fact provide the possibility that people have more time for preparing healthy food at home because they need to work less time to reach their subsistence level, and/or have more income left to spend on higher-quality, fresher and relatively more expensive food.

Regarding the travel costs, gasoline price is a typical economic determinant; we found few studies analyzing the association between gasoline prices and body weight status. Apart from that, there are other important factors determining the travel costs: factors such as the proximity of facilities, gasoline price, street connectivity, urban sprawl, etc. may make either alternative (i.e. buying fresh food and produce at the grocery store or market, or food-away-from-home) more or less appealing. These factors are discussed in-depth in the paragraph on the physical/natural environment.

Relating to physical activity, product prices are probably not a very relevant factor. Time costs, on the other hand, as well as safety (traffic, crime, accident) and prices of passive transportation (compared to those of active transportation) appear to be relevant factors for leisure-time physical activity and transport-related physical activity. As above, time costs relate to wages and to the proximity to facilities or parks and places for physical activity. The proximity, along with safety and design aspects are discussed below.

### **5.2.2.2 Meso-economic environment**

At the meso-level of the economic environment, studies primarily investigate the association between body weight status and the economic status of a neighbourhood, the so called area-level socioeconomic status (hereafter: area-level SES). The study question here is whether living in an area of concentrated deprivation is associated with overweight. Indicators used include area-level measures of income, education level, occupation and employment status, housing quality and property values, household composition, car ownership, percentage receiving some sort of public assistance, etc.

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Area-level SES does not substitute individual-level data on SES as the two dimensions theoretically work through different channels. Therefore, testing for neighbourhood SES should not replace controlling for individual-level SES characteristics (Schwartz 1994; Stafford et al. 2007:1883) and vice versa: “Even after controlling for individual-level SES, the literature consistently demonstrates that living in an economically deprived neighbourhood increases one’s odds of being obese or having higher BMI. These relationships hold using a broad range of SES indicators including unemployment rates, area income and education, percent in poverty, community disadvantage, and material deprivation”, as Black and Macinko (Black and Macinko 2008:3) conclude from their review.

Area-level SES mainly influences the risk for overweight through the physical/natural neighbourhood environment. Compared to neighbourhoods of low SES, affluent neighbourhoods may promote leisure-time physical activity by offering greater access to parks, sports fields, private health clubs and more safe places to exercise, and also have design features that draw people outside to walk (such as maintenance, greenery, and safe sidewalks), see for example the study by Gordon-Larsen et al. (2006). Low-income neighbourhoods often suffer disproportionate impacts from disinvestment and poor land use planning (Black and Macinko 2008:6). In fact, a substantial literature reports that not only active recreational facilities (public beaches, pools, youth centres, parks, YMCAs and YWCAs, dance studios, and athletic clubs) are found to be inequitably distributed across neighbourhoods of differing SES but also food opportunities (such as supermarkets, smaller grocery stores and convenience stores, restaurants and fast food outlets) (Cawley 2006:75-76; Rosin 2008:638). Affluent neighbourhoods may facilitate healthy eating, with such neighbourhoods offering more places to buy healthy high-quality foods such as fresh produce, and less fast-food outlets.<sup>20</sup> The term food desert is sometimes used in connection with the access and the proximity to the components of a fresh and healthful diet. “While there is no standard definition, food deserts have been described as places that lack local supermarkets and fresh foods, have unaffordable prices for healthy foods, are socioeconomically deprived and where residents are dependent on corner stores to purchase food” (Black and Macinko 2008:6). The cumulative disadvantage of people of low SES living in areas of low SES may expand to schools as well. So called cash-strapped schools may conclude a contract with suppliers of soft drinks and snacks that make these goods available in schools, making it readily accessible. Lack of financial resources may also reflect in the food served in school cafeterias, the availability of after-school sports programs and the

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<sup>20</sup> Such findings originate for the most part from the USA and Canada. “However, similar findings are not consistently observed elsewhere. The differences observed between the USA and other countries may reflect other influences such as the greater degree of residential segregation based on social class and race, which could influence patterns of food and drink purchase and consumption.” (Butland et al. 2007:54). Moreover, the cross-sectional evidence gives no indication regarding the causality or the direction of causality: “Rather than the provision of retail foodstuffs acting as an influence on diet, it may be that economic forces relating to supply and demand are more important, whereby healthier foods are less likely to be provided in areas where there is lower demand for them.” (Jones et al. 2007:10).

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quality of outdoor play or gym resources (e.g. Anderson and Butcher (2006b) found that school financial pressures are linked to the availability of junk food in middle and high schools).

However, there are also channels through which a low neighbourhood SES may decrease obesity, offsetting some of the factors above. For example, living in a poor neighbourhood may necessitate more active transportation, “especially if people living in these areas are less likely to own cars, rely on walking or public transportation for basic transport, and if such neighbourhoods are located near transportation hubs” (Morenoff et al. 2006:15).

A large number of studies analyzing the association between area-level SES and body weight was found. A part of these studies is included in the review by Black and Macinko (2008). In addition to the references analyzed in these reviews, we have found a number of additional studies referring to the research field. Our search in this field may have produced more references because we could also include several studies that were published after March 2007 (limitation date of review by Black and Macinko) possibly searched in a broader range of databases relating to medical, economic and social sciences.

### **5.2.2.3 Micro-economic environment**

At the micro-level, associations between body weight status and the economic environment primarily relate to the economic status of an individual or a family. Out of the 677 studies found 318 studies exclusively analyze the association between body weight status and some measure of income, formal education, occupation or employment, food insecurity, food insufficiency, material deprivation, or economic constraints. Many more studies use at least one of these measures as a control variable. A large number of studies analyzing the association between body weight status and marital status, family size (number of children) and family structure (single-parent home) were also found. The concept behind the household variables lies in their close link to income. Marital status along with family size may further be an indicator of maternal employment, but only imperfectly; we discuss the influence of maternal employment on body weight status in the paragraph on the sociocultural macro-environment.

The relationship between SES and obesity tends to be a strong, inverse association in women, although it is somewhat less consistent in men and children. The differential impact on men and women is sometimes explained by low-paid jobs typically reserved to men tending to be more physically demanding than those more often taken up by women. Likewise, if men earn most of the household income and a high household income has a significant, negative effect on BMI for females, but not necessarily for males, this may be partially capturing the more sedentary nature of higher-income jobs (Rashad 2006:279).

Most theoretical reasoning behind the inverse relationship between individual-level SES and body weight concentrates not on physical activity but on income and eating patterns. An exception is the strand of literature analyzing how the neighbourhood environment in areas of low SES may impact physical activity patterns. This is dis-



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cussed below in the paragraph on the natural/physical environment. The inverse relationship is expected because food deprivation is rare in industrialized countries and costs associated with being normal weight can be quite high. In other words, a lower income does not translate into being short of food. Instead, food deprivation/food insufficiency/food insecurity relate to being short of *high-quality* food for what is considered to be a healthy diet in developed countries (WHO 2000:124).<sup>21</sup> “Less affluent individuals tend to eat diets that are less nutritious, more energy-dense, and low in fruits, vegetables, and unprocessed foods, although it is not entirely clear why less affluent individuals make unhealthy food choices.” (Poston and Foreyt 1999:205). In a series of publications, Drewnowski and others (Drewnowski 2004; Drewnowski 2007; Drewnowski and Darmon 2005; Drewnowski and Specter 2004) bring forth evidence that the unhealthy food choices made by less affluent individuals may be linked causally to the low cost of energy-dense foods per calorie (when compared to less energy-dense foods); see Darmon et al. (2004) for evidence from France indicating that energy-dense diets are associated with lower costs. Energy-dense foods may represent the lowest-cost option to the consumer, and the main concern in a low-income household will be to obtain sufficient dietary energy at low cost to ensure that no one would remain hungry.<sup>22, 23</sup> Consumption of high energy-dense foods has been associated with higher caloric intake, as is discussed in the paragraph on the technological environment.

Education, another important factor defining the SES and highly correlated with income, appears to be inversely associated with body weight in industrialized countries. “The observed inverse relationship between education and body weight may be partly attributable to the fact that individuals of higher educational level are more likely to follow dietary recommendations and adopt other risk-avoidance behaviours than those of low educational attainment (WHO 2000:126).

All these variables that reproduce some aspect of socioeconomic position are strongly correlated with one another. In the field of obesity, there is hardly another variable showing an equally strong and robust association between own or parental

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<sup>21</sup> See also: “Distinct from both poverty and hunger, “food insecurity is defined as a limited or uncertain availability of nutritionally acceptable or safe foods” (Drewnowski 2004:154).

<sup>22</sup> For example, Drewnowski (Drewnowski 2004) presents the following finding: “Mean daily spending on foods and beverages is estimated at approximately \$8 per person per day. Assuming a daily ration of 2500 kcal (10.4 MJ), each dollar needs to yield 1.3 MJ of dietary energy. Grains, fats, and sweets provide this easily; fresh fruits and vegetables do not.” In another paper they show that “the impact of cost on energy density was much greater than the impact of energy density on cost. In other words, deliberately selecting an energy-dense diet need not lead to lower diet costs. Conversely, restricting food expenditures will inevitably lead to more energy-dense diets”, unless people are willing to adopt unfamiliar eating habits, depart from social norms, and subsist on unpalatable foods (Drewnowski and Darmon 2005:269S).

<sup>23</sup> See also Ranney and McNamara (2002), who investigated the relation between household food expenditures and the extent to which individuals meet the Food Guide Pyramid recommendations. They found that moving to a healthier diet that meets the dietary guidelines implies increasing food expenditures. Even though the increase in spending on food is quite small for most people, at \$5–\$10 per month per individual, this expense may be significant for the low-income households.

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SES and overweight or obesity risk. Consequently, it has become standard to estimate odds ratios for SES categories when estimating obesity prevalence or to include some variable reflecting the SES in the quantitative model specification as control variable. This may also explain the large number of studies found.

A more detailed inspection of the studies in this field is unfeasible given the large number of studies found. Fortunately, there exist at least 8 reviews on the association between overweight and SES (Ball and Crawford 2005; Ball and Crawford 2006; Dinour et al. 2007; McLaren 2007; Parsons et al. 1999; Shrewsbury and Wardle 2008; Sobal and Stunkard 1989; Wang and Beydoun 2007).

A noteworthy article was written by Bostrom and Rosen (2003). They investigated whether the results may be influenced by the choice of socioeconomic measure when investigating inequalities in health, and in fact their findings suggest that the choice of measure does influence the result. This may reflect the fact that the different measures work through different 'channels'. For example, while a low income may affect body weight by restricting food choices, low formal education may affect body weight by limiting knowledge regarding what is a healthy choice and what is not. Under different circumstances, the two SES variables may lead to different body weight outcomes. A low income may be more strongly related to overweight if the costs of healthy food options are relatively high compared to those of unhealthy food options, but not otherwise. On the other hand, an effective health literacy campaign may mediate the inequality by reducing the obesity-relevant knowledge gaps. The individual components that define SES may have independent and even opposite effects on dietary intake and physical activity patterns, so that it is often very difficult to make generalizations about the impact of SES on body weight.

Another strand of literature worth mentioning relates to the question whether it is the parents SES or one's own SES that matters, and whether the SES experienced during childhood is more relevant than the current SES (Ball and Mishra 2006; Baum and Ruhm 2007; Koivusilta et al. 2006; Teasdale et al. 1990).

As is the case with most study questions in this review, it is difficult to derive causality from an association. In this case, it may be even more challenging because causation potentially runs in either direction: a low SES may cause overweight or higher body weights may lead to a lower SES, either due to reduced physical mobility or due to employment discrimination (Sorensen 1995). There is a good deal of research investigating either direction of causality, and there are indications that causality runs in both directions, instigating the outcome much like in a vicious circle.

What is more, there may be personal characteristics influencing both the probability of a high body weight and a low SES, such as self-discipline, self-control, or the time preference rate. These factors may cause the correlation between SES and body weight. We have found studies analyzing the association between the time preference rate and body weight status. Time preference is the rate at which people are willing to trade current utility for future benefit, thus it reflects patience. The time preference influences body weight since a healthy body weight is based on abstaining from some immediate gratification from eating in order to not gain weight and thus keep enjoying good health in the future. A higher rate of time preference could re-

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duce investment in exercise and increase caloric intake and therefore increase weight. Becker and Murphy (Becker and Murphy 1988:685) put it clear enough: “drug addicts and alcoholics tend to be present-oriented, while religious individuals and joggers tend to be future-oriented”. Other indicators of the rate of time preference are the saving rate, consumer debt, and investments in formal education.

It is important to not confuse the time preference rate with a lack of information regarding the future risks of an activity. People with a high preference for the present may rationally engage in activities, knowing that they are linked to future health risks. In other words, while fully informed people with a high time preference rate would ‘do it the same way all over again if they could’, people with a lack of information would not behave the same again once they realize what consequences their actions have.

The extents to which consumers acquire and use information about emerging opportunities have been linked to levels of formal education. More-educated individuals may place a higher value on future consumption than present consumption and find choosing activities that carry lower health risks optimal. Kenkel (1991) finds that more schooling is associated with healthier lifestyle choices regarding smoking, drinking and exercise. While part of the relationship between schooling and the health behaviours is explained by differences in health knowledge, most of schooling's effects remain after differences in knowledge are controlled for. Thus, formal education, time preference rate, SES and body weight are closely interlinked.

Not necessarily related to SES but perhaps imposing a personal barrier to a normal body weight (just like the available monetary or informational resources are) is the available time. One study estimates whether time constraints do in fact influence the risk for overweight or obesity, and it further assesses whether personal barriers such as time are more or less important than neighbourhood environment barriers. Another study (Goode et al. 2008) investigates whether the distinction between employed and not-employed individuals represents the different constraints that the two groups face, as the average employed person has more money and less time and the average not-employed has less money and more time. As physical activity requires time and healthy quality food requires money, the two groups may or may not exhibit differences in obesity risk. Employment status may be an indicator of time constraints. Thus, unemployment may not only increase the risk for overweight through a lower SES but also decrease the risk for overweight through more time. Several studies were found analyzing the association of employment status, overtime work, and non-standard work schedules and body weight. However, employment status as an indicator cannot separate time constraints from money constraint, which relates to the relationship of SES to obesity.

### **5.2.3 Sociocultural environment**

#### **5.2.3.1 Macro-level sociocultural environment**

Associations between body weight status and the macro-level sociocultural environment have been studied with regard to aspects relating to housekeeping (in particular food preparation) and parenting.

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The rising female labour force participation (along with rising educational attainment of women) increases the opportunity cost of time. The traditional division of labour in home food preparation is thereby obliterated. Yet, women “still tend to take responsibility for the health and well-being of the family but less and less for the more time- and energy-consuming domestic chores concerned with cleaning and the preparation and serving of food” (WHO 2000:132). As a result, the food preparation is increasingly being outsourced, resulting in a shift from freshly prepared meals eaten at home to food eaten away from home in restaurants and fast food outlets, pre-prepared food such as convenience food, and take-away food. The trend of the vanishing traditional division of labour at home has been accompanied by the following two trends, which reinforced the impact. First, there has been considerable technological innovation in the mass preparation of food, such as vacuum packing, improved preservatives, deep freezing, artificial flavours and microwaves have enabled food manufacturers to cook food centrally and ship it to consumers for rapid consumption, requiring very little additional time-input from the consumers. Second, there have been shifts in the relative food prices (i.e. price of food relative to other consumer goods, price of low-energy-dense food relative to high-energy-dense food, price of freshly prepared food relative to pre-prepared food, etc.).

Thus, the sociocultural change – accompanied by technological and economic changes – has made eating pre-prepared food the easier choice. The distinction between food at home and food away from home is important for the overweight epidemic because consumers typically have less information about the calorie content of foods they eat away from home (Cawley 2006:72-73) and less control over the portion sizes they receive. To what extent this may be detrimental to a healthy body weight is described in the paragraph on the technological environment.

As an additional possibility, Philipson (2001:4) relates the rising obesity rates to the rising female labour force participation by means of the returns in the matching market. To the extent that women can support themselves as a consequence of their employment in the labour market they do not value marriage as highly as when their only good job opportunities were within the marital household. With these returns to marriage declining, women no longer need to stay thin ‘for the husband’ but may concentrate more on their labour market returns (the increases in divorce rates are sometimes related to this same increase in female economic independence). This may explain why women have gained more weight than men over time.

Apart from the impact on food preparation, the vanishing division of labour at home also affects child upbringing. In particular maternal employment, possibly along with non-standard work schedules, may affect the recreational activities of children. Parents being absent when the child comes home from school have more difficulties supporting active leisure-time activities of the child (lack of transportation, safety, monitoring, incitement, etc.) and unsupervised children of working parents may substitute active recreational activities with sedentary screen time (TV, computer games, etc.). Thus, the costs associated with physical activity of children increases for parents with their working hours, with the lack of safe places for children to be physically active in the nearby neighbourhood (i.e. the physical/natural environment), and with

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the increasing benefit of sedentary recreation accruing from the increasing options and technological innovations (number of TV channels, DVDs, computers, internet, game consoles, etc., i.e. the technological environment).

We consider it important to point out that the implications of these findings are by no means that ‘a woman’s place is in the kitchen’. Instead of aiming to reverse (irreversible) sociocultural changes (which, besides, are accompanied by numerous additional and trends in technology and economics!), it is potentially more rewarding to emphasize the importance of improvements with respect to a better compatibility of family and work in general, and of appropriate school schedules and after-school programs for children in particular.

In addition, it is important to keep in mind that there may also be an advantageous effect of maternal employment on childhood weight, namely if households where the mother works have more money with which to purchase more healthful meals. After all, the negative association between low household income and overweight status is a very robust finding. Alternatively, low income may constrain parents’ healthy eating or physical activity options to offer their children regardless whether they work or not, and employment of both parents may then make no discernable difference. Anderson et al. (2003b:41) conclude from several sophisticated statistical analyses that “the estimates [...] strengthen the conclusion that there is a causal impact of mothers’ average hours worked per week on children’s obesity for families in the *top quartile* of the family income distribution.”

### **5.2.3.2 Meso-level sociocultural environment**

Associations between body weight status and the meso-level of the sociocultural environment has been studied with regard to community social capital. Social capital was related to the following indicators: social cohesion, social support, networks, club membership, civic participation, and others.

The argument made is essentially that social capital and relationships enhance an individual’s psychosocial disposition and the ability to cope with stress, which again negatively influences the risk of overweight and obesity.

### **5.2.3.3 Micro-level sociocultural environment**

Associations between body weight status and the micro-level of the sociocultural environment has been studied with regard to body weight norms among the social network and to family rules.

There is evidence for the existence of a so-called social multiplier effect. This corresponds to the positive correlation of body weight status within a social network, e.g. among household members, partners or peers. This multiplier effect is likely to be at least partly responsible for the very fast pace at which overweight and obesity rates have been spreading in recent years.

The underlying hypothesis is that a social network where overweight and obesity is common (i) decreases an individual’s psychosocial cost of being overweight (via body weight norms) and (ii) increases an individual’s cost of healthy physical activity

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or eating behaviour because there is less support (in particular company) for it from the network, or (iii) increases an individual's benefit of undertaking unhealthful activities in the company of family and friends. As such, individuals with unhealthy lifestyle exert a negative externality on the people in their network.

Special attention should be given to the influence of the family on children. During the first few years of a child's life, the family is a child's main social network, determining the support and rules the child experiences with respect to being physically active and eating healthy (such as snacking, eating meals while watching TV, eating breakfast, etc.). Apart from giving support and rules, parents are responsible for both food options in the home and for engaging children in leisure-time and transport-related physical activity. Children in general have less autonomy in choice than adults. An obesogenic family environment may render healthy physical activity or eating behaviour prohibitively costly for a child, namely by not even providing the opportunity. Once children grow older and move into adolescence they become more autonomous, but some childhood lifestyle patterns remain imprinted. Thus, it is of particular importance to pay special attention to the family and home as potentially obesogenic environment.

How parents' own decisions translate to children's risk of being overweight or obese is mirrored in the robust, strongly positive correlation between parental (in particular maternal) and child body weight status. Clearly, genetic influences are likely to also play an important role in this association, but they are not the only explanation as partner's and peers' body weights also exhibit a strong positive correlation, often referred to as the social multiplier or network effect. Unfortunately, it is difficult to disentangle the genetic impact and the influence from the family environment on a child's risk of being overweight.

The multiplier effects of the social network may seem as a disadvantage, as obesity spreads faster the more prevalent it is. However, there is also the other side to this coin. The multiplier effects, which have "shaped up as negative externalities in recent years, may be used as a source of positive externalities by spreading healthy behaviour. "Once appropriate levers are identified to turn the tide, it may be possible to transform those negative externalities into positive ones, and this may generate a similarly rapid spread of healthier habits across household members and social networks, and a relatively rapid containment of overweight and obesity" (Sasso et al. 2009:41).

#### **5.2.4 Technological environment**

In the domain of the technological environment, the distinction between micro-, meso-, and macro-level of the technological environment is not relevant since technology only really happens on the macro-level.

An explanation of the rising obesity rates (and possibly even the difference in obesity rates between developed and developing countries) is that body weight status is related to technological changes. Generally, technological progress has the aim of making things "easier" for us and to engineer physical effort out of the environment (Butland et al. 2007:52). This is mirrored in technology

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- (a) Reducing the physical exertion in general
  - (b) Altering the costs and benefits of leisure-time activities
  - (c) Increasing the availability of certain foods, and
  - (d) Increasing the affordability of foods through prices and incomes.

**a) Technology and physical exertion**

The hypothesis that technology has increased obesity by reducing the physical exertion has been studied with respect to the physical strenuousness of the job and to transport-related physical activity.

The shift in employment from manufacturing to services, industrial automation, mechanization, and computerization are said to have reduced the physical strenuousness of the job (Rosin 2008). In developed countries, jobs requiring heavy manual labour have been largely replaced by jobs in service and high technology sectors, which require minimal physical exertion. If the labour market does no longer require and thus value physical activity, the benefits of being physically active decrease. Moreover, engaging in physical activity off the job has become costly, mostly through the rising opportunity cost of leisure time. Thus, instead of “being paid to exercise” as in agricultural and early industrial societies, one needs to pay for exercise these days (Propper 2004:3).

A somewhat related argument is made by Rashad (2003). He argues that the change in the nature has brought about higher levels of stress, i.e. a psychological or psychosocial job strain which replaces the physical strenuousness of jobs. Since stress has been “known to cause irregular eating habits, particularly hunger pangs at night or in the wee hours of the morning”, work-related changes in technology have had both an impact on energy expenditure as well as energy intake.

Technology and its increasing reliance on and availability of cars and other modes of passive transportation (such as elevators) have brought about reductions in transport-related physical activity. This effect is potentially reinforced by having led to a transformation of the urban structure. This new environment is aligned to make way for the passive forms of transportation which is essentially an environment that discourages walking or cycling.

The reduction in the physical exertion may not only affect the energy expenditure but also the demand for food. There may be a downward shift in the demand for food resulting from the more sedentary lifestyles. Such a downward shift in the quantity of food demanded, however, may again be offset by decreasing prices of food, see below.

**b) Technology and leisure-time activities**

The hypothesis that technology has increased obesity by altering the costs and benefits of leisure-time activities has been studied with respect to rising wages and the availability of sedentary leisure options.

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Technological progress increases the productivity of human labour. According to economic theory, wages rise when labour productivity rises. Thus, technology has produced rising wages, which again reflect rising opportunity costs of time. The substitution effect of rising wages would induce people to spend less time preparing fresh meals at home, monitoring physical activity of children, and being physically active oneself because this requires time and time is costly. This negative effect of rising wages on body weight status may be countered by the income effect which makes individuals have more spare time because they can subsist equally well with less work time. Also, the technological progress in transportation and labour-saving devices may have freed up time for leisure-time physical activity.<sup>24</sup> While there is in fact evidence that working hours have decreased over the years, transport-related progress actually appears to result in less spare time than in more spare time. Time spent in cars and other modes of passive transportation has increased with progress as the demand for mobility and the distances to be covered on a regular basis have increased. There is an interesting strand of literature on how time-use has changed in the last decades among children (Sturm 2005a; Sturm 2005b).

Technological progress has increased the availability of sedentary leisure options, such as TVs, number of TV channels, and the entire IT revolution with computers, video games, internet, DVDs, etc. The benefit of sedentary leisure has thus increased, diverting people from spending their time with active leisure-time activities. In addition to TVs displacing physical activity they may also influence energy intake which may increase in response to the effective and vast marketing and advertising that is taking place through the global mass media.<sup>25</sup> The wide availability of TVs, children's channels, and internet proves to be a very effective way to reach people (judging by the amounts expended on TV advertising). Consequently, exposure to commercial advertisements for food, in particular of high-calorie energy-dense food (see below), is considered substantial, in particular for children (Rosin 2008:640; WHO 2000:132).

It has not been studied whether obesity is associated with a change in the benefit of leisure-time physical activity which was potentially increased as a result of technological progress in sport gear.

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<sup>24</sup> Likewise, there may be substitution between different types of physical activity: "Effects through the allocation of time show that on-the-job exercise is substituted by leisure devoted to off-the-job exercise. That is, the jogging and gym 'revolution' is a substitution brought about by technological change at work and may offset the rise in obesity due to work-related technological change." (Rosin 2008:635).

<sup>25</sup> "Television viewing has been proposed to cause weight gain through 3 main effects: by displacing physical activity, by depressing metabolic rate while watching TV, by adverse effects on diet quality, either while watching TV or at other times, primarily due to food advertisements. Of these possibilities, the strongest evidence relates to diet." (Ludwig and Gortmaker 2004:226).



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### **c) Technology and food**

“Technological advances in cultivating, preserving, producing, transporting and storing foods have increased the year-round availability of a wider variety of foods to a larger number of people” (WHO 2000:131).

The hypothesis that technology has increased obesity via the availability of certain (and new) foods has been studied with respect to the influence of overall agricultural output and productivity and of the availability of processed (or pre-prepared) food.

Technological progress has increased agricultural productivity. The larger output has lowered the prices of food (assuming market forces are not entirely deranged by agricultural policies), making the price of calorie consumption cheaper. Lower prices contribute to increasing food intake and thus may cause overweight.

Moreover, technological progress has increased the availability of certain foods, in particular of processed food. Innovations in the mass preparation of food, such as vacuum packing, improved preservatives, deep freezing, artificial flavours, distribution, and microwaves have enabled food manufacturers to cook food centrally and ship it to consumers for rapid consumption. The consumption of such ‘convenient foods’ requires very little additional time-input from the consumers, and this reduction in the cost of consumption may lead to higher (in particular to more frequent) consumption.

Generally, technological progress need not necessarily cause overweight if these technologies are used for the production, preparation and distribution of healthy food. Of course, technology has also helped the fast distribution and year-round availability of fresh produce. Nevertheless, generally “foods that are consumed in more or less the same form that they leave the farm, like fresh fruit, stand to gain less from advances in packaging and processing. Foods that involve significant amounts of preparation benefit most from the new technologies.” (Cutler et al. 2003:106) Thus, technological progress has led to a disproportionate increase in these ready-to-eat products which are generally of higher energy density than fresh food. This appears in data on the proportion of total food spending that goes to farmers as opposed to food manufacturers.

This trend has been reinforced by the fact that businesses cannot stand still in order to survive in the modern competitive market economies, but need to grow and maintain or increase profits. And if this cannot be done by increasing sales of basic foodstuffs (for example because the populations do not grow substantially in developed countries), market shares and profits can be increased by product differentiation and innovation, i.e. “by turning basic foodstuffs into other, more expensive products (i.e. processed, pre-packaged foods).” (WHO 2000:131) Fresh foods, such as apples and potatoes, are much more homogenous between the different suppliers, so that there is less opportunity for winning over customers from competitors or realizing a mark-up (and thus profits) because customers will simply switch to the competition if there is no product differentiation and customer loyalty. This is mirrored in the advertising strategies of food suppliers: while it seems profitable to advertise a specific soft drink

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or a microwave menu (judging from the amounts that are invested in advertising), there is very little effort undertaken to advertise fresh foods because such advertising would equally play into the hands of the competitors. Indeed, “[...] far more money has been spent on promoting high-fat/energy-dense foods than on promoting healthier foods” (WHO 2000:132).

Moreover, it is sometimes claimed that humans have a predisposition through the evolutionary process for energy-dense food in order to be prepared for times of food scarcity (Knickman and Orleans 2004:175; Rosin 2008:10). Energy-dense foods, in particular sweet and fatty foods, are associated with higher palatability, and they have been associated with higher energy intakes in clinical and laboratory studies (Drewnowski 2004:155); see e.g. the review by Prentice and Jebb (2003). Thus, energy-density in foods tends to increase palatability (thus customer loyalty), energy intake, and consumption (WHO 2000:110).

In short, how can the increased availability of pre-processed foods have an impact on body weight status? The reasons are manifold:

*First*, pre-processed foods are often termed convenience food “because they are considered quick and easy to obtain and consume” (Banwell et al. 2005:567); growth in technologies such as microwave ovens that facilitate consumption of pre-prepared foods require very little additional time-input from the consumers. With decreasing time costs of preparation, consumption may increase. Wansink (2006) finds experimental evidence that the amount of food consumed increases as the effort to eat it decreases.

*Second*, the energy-density in pre-processed foods tends to be higher, and this may promote intake through a sense of hunger and through high palatability.

*Third*, as the food composition is increasingly being placed in the hands of manufacturers, consumers lose control over the preparation and nutrient content of the foods they eat. Thus, “it is becoming increasingly difficult for consumers to know the micronutrient content of their food, because the fat and sugar content is manipulated during processing” (Banwell et al. 2005:567).

*Fourth*, the manufacturer (or fast food outlet or restaurant) determines the portion size of what is considered a ‘meal’. This portion size is generally larger than the portion size someone would serve at home, which leads to overeating. Jeitschko and Pecchenino (2006) propose a theoretical model of this: At home, consumers are free to choose any size of meal, which depends, among other, on hunger. This stands in contrast with the problem of providing an optimal standardized meal size (in restaurants or of pre-prepared food) that maximizes the welfare of the typical consumer. It is rational for suppliers to offer a portion size which is larger than the average portion chosen by the population at large at home as long as it is less costly to increase the portion size than to lose potential customers (possibly to the competition) for whom the portion size would be too little. The additional costs of increasing the portion size have been decreasing with the decreasing food prices, providing an incentive to increase portion sizes. One could argue that – independently of the decisions of the

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supplier, the consumer always has the option of not eating the entire portion served. However, because the additional costs of continuing eating the portion served is zero (the meal is already paid for, and thus sunk costs are sunk) while there will be some benefit to continuing eating, the consumer will very probably eat more than he would at home (see e.g. Wansink (2006), Diliberti et al. (2004) or Rolls et al. (2002) for experimental evidence that people served large portions eat more regardless of all other facts). Interestingly, Jeitschko and Pecchenino (2006:447) find that “the often maligned option of super-sizing alleviates this problem that may be associated with discrepancies between home-cooked meal and restaurant meals” as average consumption will actually decrease relative to the single portion case when there are two meal sizes over which the consumer can choose. Another problem that may be associated with portion size is that according to experiments, it is more difficult to correctly estimate the caloric content of a meal when the meals are large portion sizes (see e.g. Wansink and Chandon (2006)).

*Fifth*, the incentive for generating profits and increasing their market share motivates food manufacturers to increase sales and consumption through effective marketing and advertising.

#### **d) Technology and affordability**

The hypothesis that technology has increased obesity via the affordability of foods has been studied with respect to food prices and income. Innovations in agriculture, storing, preparing and distributing food has lowered food prices and thereby increased consumption. Technological progress has raised the productivity of human labour and thereby increased wages. An increase in income raises the opportunity cost of time and promotes food demand given that food is a normal good. However, rising incomes may also depress demand for inferior (energy-dense) foods or increase spare time because of the income effect.

### **5.2.5 Physical/natural environment**

#### **5.2.5.1 Macro-level physical/natural environment**

More than 30 studies have found a variation in obesity rates between relatively large geographic regions (ranging from countries, regions, counties and districts to metropolitan areas), with and without controlling for other factors. The existence of this large-scale variation may be linked to macro-level factors of the physical/natural environment, among other, possibly synergistic factors (such as regional economic strength, legal and policy factors, norms and values of the population, and even genetic variations). Acculturation of immigrants (or length of time living in the adopted country) and its effect on body weight has also been assessed in a number of studies. Acculturation may serve as a proxy to the macro-level physical/natural environment, but there likely are a number of further possible causes for a lifestyle transition after acculturation.

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Factors relating to the macro-level of the physical/natural environment that were studied in association to body weight status are (a) the degree of urbanization within a country, and (b) aspects relating to the climate (such as temperatures, change of seasons, etc.).

**(a) Degree of urbanization**

Differences in urbanization are reflected in the land-use characteristics. Land-use patterns in urban versus rural areas may influence the opportunities for eating away-from-home (density of restaurants and other food outlets), for leisure-time physical activities, and for transport-related physical activity. For example, the high-density, centralized land-use patterns of most European metropolitan areas may promote walking instead of driving a car (Rabin et al. 2007). Population density may also force people to use public transportation – which requires more physical activity than taking the car as the need to get to and from the transit stops requires walking (Mandal and Chern 2007). On the other hand, crime or traffic may deter outdoor exercise and leisure activities, restricting physical activity options. Moreover, there may be differences in the employment patterns, with work being on average more physically demanding in rural areas than in highly urbanized areas. Finally, some differences in obesity rates between urban and rural areas may also be driven by socio-economic differences (e.g. lower income).

**(b) Climate amenity**

Regional (and seasonal) variation in physical activity may arise from differences in the climate amenity. Regions with higher climate amenity are more inviting for outdoor physical activity (which does not depend on the availability of indoor facilities), active transportation, and a general reduction in leisure-time spent passively at home. Secondary to the increased activity levels, decreased caloric intake in warmer climates (just like seasonal alterations in diet) may additionally contribute to body weight (Dietz and Gortmaker 1984:623).

Unusual hypotheses were offered but not tested by Baillie-Hamilton (2002) and by Ternak (2005). Baillie-Hamilton argues that the current level of human exposure to synthetic organic and inorganic chemicals may have damaged many of the body's natural weight-control mechanisms, and that these effects, together with the wide range of additional factors may play a significant role in the worldwide obesity epidemic. Ternak hypothesizes that obesity (as well as the growth in height) may be associated with the mass consumption of antibiotics starting 40-50 years ago, by influencing the human body directly as well as indirectly via environment.

**5.2.5.2 Meso-level physical/natural environment**

At the meso-level, associations between body weight status and the physical environment can relate to the (a) neighbourhood environment and to (b) the school or work environment.

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## (a) Neighbourhoods

Morenoff et al. (2006) demonstrated that BMI varies substantially across neighbourhoods, even after adjusting for individual-level demographic and socioeconomic factors that may account for some of the selection of people into neighbourhoods. We found a large number of studies studying the association between body weight status and neighbourhood characteristics. Nearly as large is the number of indicators that were used in all these studies to reflect neighbourhood characteristics. 4 reviews were found on the association between obesity and the built (and socioeconomic) neighbourhood aspects (Black and Macinko 2008; Booth et al. 2005; Jones et al. 2007; Papas et al. 2007). The three recent reviews are more comprehensive than the one by Booth et al. due to the important contributions to the literature made in the years 2006 and 2007. The review by Jones et al. is extensive because they also included studies with outcomes other than body weight (e.g. physical activity levels, etc.). Their results are narrative and thus not as clearly arranged in tables as the ones by Papas et al. and Black and Macinko. We will primarily refer to the two reviews by Papas et al. and Black and Macinko.<sup>26</sup>

Concerning the energy intake, the physical/natural environment is most likely to affect the *place* of consumption as a key factor out of the '4 Ps' product, price, place, promotion. The prevalence of fast-food outlets, restaurants, grocery stores, or fresh markets in the neighbourhood influences the acquisition costs (in terms of effort or the time required) related to food consumption. For example, the higher the availability of fast-food in the neighbourhood relative to the options to buy fresh produce, the lower are the incentives to eat healthy as the unhealthy alternative becomes more convenient. In this regard, the term 'place' is to be viewed more broadly than a geographical spot; it refers to accessibility in general, i.e. the distribution channels of where, when (24h availability?) and to whom (age restrictions?) the goods are made available. The studies differentiate between the availability of and proximity to (full-service) restaurants, fast food outlets, and grocery stores. Both Black and Macinko and Papas et al. included some of those references in their reviews.

Concerning the possibilities for energy expenditure, the physical/natural environment is most likely to affect leisure-time physical activity and transport-related physical activity. Leisure-time physical activity may be influenced with the recreational resources and land-use mix in the neighbourhood. Recreational resources in the neighbourhood (such as parks, forests, playgrounds, health clubs, etc.) may increase leisure-time physical activity as the associated costs (such as time and effort) are lower when such resources are easily accessible, well-maintained, and safe. For example, high land-use mix is sometimes assumed to encourage physical activity because of

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<sup>26</sup> In addition to the references analyzed in these reviews, we have found a number of additional studies referring to the research field. Our search results in this field were more comprehensive because we (i) could also include several studies that were published after march 2007, (ii) also included discussion papers that have not (yet) been published in journals, (iii) searched in a broad range of databases relating to medical, economic and social sciences, and (iv) may have applied a broader environment concept.

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the higher diversity of available resources nearby and because it might create safer environments due to “the number of eyes on the street” (Morenoff et al. 2006:14). The safety aspect is especially important for children: safety concerns of parents or society in general may discourage unstructured physical activity during leisure-time for children, especially if parents do not have the time or possibility to monitor the children and keep them safe from the risk of accidents, traffic, ‘stranger danger’, and even litigation.

The neighbourhood also defines the need for and the costs associated with transport-related physical activity.

“Movement within urban areas was traditionally accomplished on foot, bike, horse, and through various forms of public transportation that required some walking from station areas to actual destinations. The compact pre–World War II city was designed to support these forms of transportation. More recently, however, transportation investments and land-use decisions have formed a physical environment that has established strong disincentives to active transportation, that is, movement between destinations under human power.” (Frank 2004:146)

Urban sprawl, i.e. the proximity to a variety of destinations, or density, is often used to measure the need for transportation: The more closely situated places and destinations are, the more likely it is that people can walk there (Morenoff et al. 2006:14). Along with certain characteristics relating to the transportation systems, urban sprawl can discourage active transportation and promote the substitution of public transportation, walking or biking for driving. These aspects can influence the costs associated with different modes of transportation, both the monetary costs (e.g. gas prices, car parking fees, reduced energy consumption of modern cars, public transport fees, etc.) and the non-monetary costs (time requirements; connectivity of roads, sidewalks and bike paths; traffic safety; air pollution; pleasantness, convenience, and comfort such as public transport quality and frequency). See Plantinga and Bernell (2005) for an economic framework on the link between land use and obesity; they also address the important aspect that there may be self-selection of a specific kind of people into certain neighbourhoods (e.g. that people who do not value physical activity do not choose their neighbourhood with regard to physical activity options). Urban design that favours the car and marginalises cyclists and pedestrians increases the use of and the reliance on cars. This can evoke not only direct effects on physical activity (less physical activity because the transportation becomes passive) but also indirect effects. The indirect effects reduce physical activity because there is less time available for physical activity as the need of and the possibilities for mobility and commuting increase and the time used for transportation increases despite the fact that driving per se would be a less time-consuming option of travelling (e.g. because of larger distances travelled and traffic congestions) (Plantinga and Bernell 2005:475).

The relatively large number of studies conducted in this field assessed the association between body weight and factors relating to the following features of the built environment:

- 
- Proximity<sup>27</sup>: land-use mix, urban design, diversity, distance and density of residential, commercial (including grocery stores and restaurants), recreational (green spaces such as parks and forests, public open spaces, playgrounds, gyms, etc.), industrial, and other resources, accessibility of opportunities to exercise, population density, dwelling density, urban sprawl<sup>28</sup>
  - Connectivity<sup>29</sup>: transportation infrastructure (public and private), physical infrastructure of roads, intersection density, sidewalks and bike paths, sloped terrain
  - Design: aesthetics, maintenance (physical disorder and dereliction, garbage, etc.), general attractiveness, environmental condition (such as air pollution), amount of vegetation surrounding the residence
  - Neighbourhood reputation, residential stability, safety (police presence, crime, traffic, unattended dogs), and social nuisances
  - Area deprivation (area-level SES)
  - Social support and social capital, such as the social organization of the community (i.e. sociocultural environment of the neighbourhood)

An allocation of the references into one of these categories is hardly feasible because many studies simultaneously address factors from more than one category and because of the large number of references found. Moreover, many characteristics are closely related and not easily attributable.

## **(b) Schools**

The school and work environment are important because it is where people spend a majority of their time, where they obtain some of their meals every day, and where they are engaged in physical activity or restricted to sedentary work.

A phenomenon known in particular in the US and in Canada and termed 'freshman fifteen' describes the substantial weight gain experienced by some students during their first year away from home in college (Anderson et al. 2003a; Butler et al. 2004;

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<sup>27</sup> "Proximity refers to the availability of common destinations (e.g., places of work, stores, restaurants, and recreational facilities) within a short distance of one's residence and is conceptually related to measures of population density, housing/building density, and the mixture of land uses (e.g., residential, commercial, and industrial). Areas with higher density tend to offer a greater number of destinations within close proximity to a person's house, and areas where land uses are mixed tend to offer both a greater range and number of destinations." (Morenoff et al. 2006:13)

<sup>28</sup> "While there is no widely accepted definition of sprawl, many associated it with low-density, discontinuous, and/or decentralized development." Low density can, for example, be measured as the ratio of population to the area of developed land. (Plantinga and Bernell 2005:474)

<sup>29</sup> Connectivity is the degree to which we can traverse between trip origins and destinations in a direct path (Frank 2004:151) "Connectivity [...] can be studied by counting the number of road intersections or transit stations in a given place, by calculating the travel distance between locations on a street grid, or by tracking the time it takes to travel between locations via public transit systems." (Morenoff et al. 2006:13)

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Hovell et al. 1985). This change may be associated with unhealthier (often cheap) food choices in the proximity of colleges or with the increased dependency on the school food environment. Children may be particularly susceptible to the school environment, as the food served in the school food program and to be purchased in vending machines or in classroom fundraising may be their only option. Moreover, PE classes, structured after-school activities and the availability of outdoor play or gym equipment offered in school may be an important (maybe the only) opportunity for some children to be physically active (even if school PE may crowd out leisure-time physical activity for some other children, as critics sometimes state).

### **5.2.5.3 Micro-level physical/natural environment**

At the micro-level of the physical/natural environment, studies were found analyzing the association between body weight status and the home food environment. No studies have been found on the home physical activity environment such as home fitness equipment.

The home food environment encompasses the food choices available in the house. It is of particular importance for children, as it often constitutes the only options they can choose from. Unfortunately, we have found no studies explicitly assessing the association between body weight and the home food environment. As a proxy for home food environment, however, we have found studies on the association between body weight and the frequency of fast-food meals or food-away-from-home. Most notably, among them are (at least) 2 studies (Boutelle et al. 2007; Veugelers and Fitzgerald 2005) that assessed the impact on children and adolescents. While there may be considerable self-selection bias with respect to fast-food consumption in adults, the effect on children may be less endogenous and thus better approach an externally valid estimate of the impact of fast-food consumption on body weight status.

Further, parental body weight status may serve as a proxy for the home food environment. Apart from the shared genetics, parents and children in particular share the home food environment. It is thus likely that the food environment in a home with overweight parents will be less healthful than that of normal weight parents (through some sort of parental self-selection). It is difficult (if not impossible) to disentangle the genetic influence from the influence of the shared home environment. However, there is support for the impact of the shared environment on the body weight from studies that find evidence for the multiplier effect among peers, i.e. a correlation between peers' body weight status, where genetics do not play a role.

### **5.2.6 Policy measures**

The studies contained in the policy measures column relate to aspects from the five domains of the environment. We nevertheless sort them out and create a new column because they evaluate how an "artificial" change in the variables – achieved by means of policy – is associated with overweight/obesity. Mostly, policy measures are



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undertaken on a macro-level. Here, we classify the different policy measures to the macro-, meso- or micro-level according to the level of the variables they were aimed at. For example, legislation on PE time in schools aims at changing the school environment. Thus, legislation on PE is located on the meso-level of the policy column.

Since the large total number of studies found in this review renders an in-depth analysis of the studies impossible, the policy studies provide an ideal opportunity to “dig a little deeper” because they have the capacity to provide an insight into the different ‘boxes’ across the thematic map. Further, the policy studies are of particular interest as they examine the impact of changes that may occur with less inevitability than many of the sociocultural, economic, and technological changes did. Thus, the studies that evaluate policy measures will be examined more in-depth in the next section.

### **5.3 In-depth review of policy measures**

The literature search produced 45 studies that empirically assessed the association between some policy measure and body weight status.

Out of these 45 studies 23 relate to policy measures that impact the SES of individuals and families (thus the micro-level economic environment). The policy measures are income support programs or laws, school food (such as the US National School Food Program) and food assistance programs (such as the US Food Stamp Program), and public housing assistance.<sup>30</sup> 8 out of the 45 studies relate to a meso-level environmental factor and are essentially evaluations of interventions conducted in schools, at work or at the community level.

The remaining 14 studies relate to policy measures aimed at a macro-level environmental factor (see Table 1 above). Specifically, these are the PE requirement law (1 study), smoking policies (5 studies), education policies (2 studies), environmental policies (2 studies), and food market regulations (7 studies) such as food taxes, agricultural policies, nutrition labelling and market entry ease in general.<sup>31</sup> Some studies evaluate the impact of several policy measures so that the sum of studies per policy measure field exceeds the total of 14 studies.

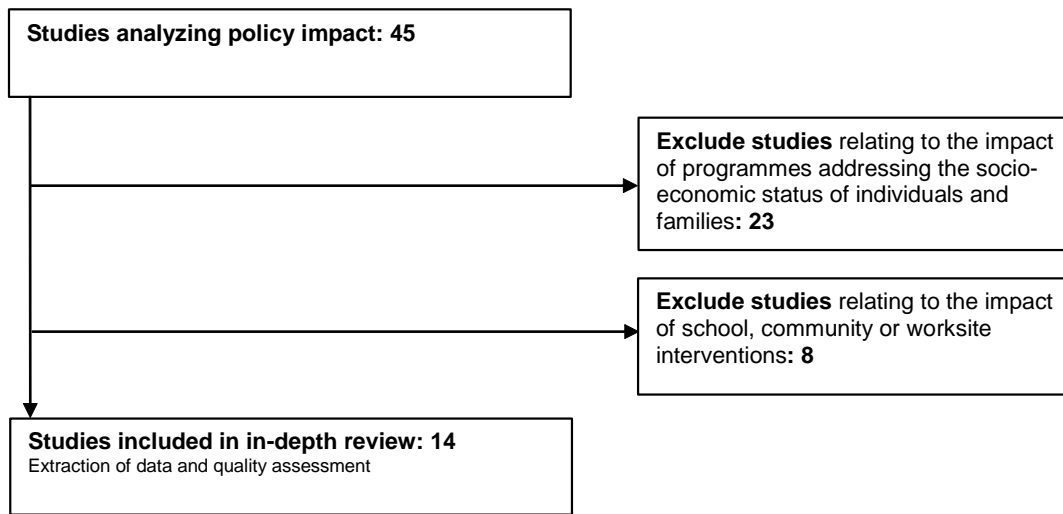
In this in-depth review on the association between policy measures and body weight status we concentrate on the 14 studies that relate to the macro-level environment. The reason for this is that the macro-level environment is of particular interest to the Swiss Federal Office of Public Health as it is the authority that is best apt to realize macro-level public health policies. The flowchart for the in-depth review is depicted in Figure 7:

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<sup>30</sup> Dinour et al. (2007) propose a conceptual framework on the impact of the Food Stamp Program on body weight status.

<sup>31</sup> Martin (2005) proposes a theoretical model on the effects of a tax on energy-dense food on body weight status.

**Figure 7** Flowchart describing identification of literature for in-depth review



In the following we present the results of the in-depth review for the studies relating to

- (a) Physical education requirement law
- (b) Smoking policies
- (c) Education policies
- (d) Environment policies
- (e) Food market regulations (taxes, agriculture policies, nutrition labelling, etc).

#### **(a) Impact of the physical education requirement law**

Making use of a quasi-natural experiment, Cawley et al. (2007) studied whether the US state legislation regarding the PE credit requirement (in credits earned each school year by participating in PE classes) had an effect on high school students' body weights or the probability of overweight. They found no effect on either BMI or the probability of overweight. Their results do suggest, however, that state PE requirements are effective in increasing the amount of time that students are physically active in PE. This second result, that mandatory PE increases physical activity in PE classes, is somewhat intuitive. As possible reasons why physical activity in PE classes increases but the effect on BMI held off the authors specify that it might be due to BMI being a noisy measure of fatness as it does not distinguish fat from muscle. Also, the schools may fail to comply with state regulations, or PE classes may do little to promote exercise and to assure that each student is physically active. Students may also engage in offsetting behaviour, e.g. by decreasing exercise outside of school in response to any increased exercise during the school day. Such crowding out need not take place, though. Cawley et al. found a positive effect of the PE credit requirements on overall physical activity, at least for girls.

**Table 2** Data extraction table: PE requirement law

Reference	Outcome indicator	Determinants	Study population					Results			Quality score*
			Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Cawley et al. (2007)	BMI overweight rate	self-reported schools / state law on PE requirements (credits to be earned) according to SONR	YRPSS	US nationally representative for high school students of grades 9 through 12	36 884 (pooled sample of years 1999, 2001 and 2003, without observations with missing values regarding weight, height, or physical activity)	1999-2003	US	no effect	no reduction in BMI overweight rate	sophisticated instrumental variable model, addressing problems of several sources for bias (e.g. self-selection of physically active students in PE classes; finances of schools in low-income areas may influence the number and quality of PE classes offered)	1/7/0

Cawley, J., C. Meyerhoefer, et al. (2007). "The impact of state physical education requirements on youth physical activity and overweight." *Health Economics* 16(12): 1287-301

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

YRPSS: Youth Risk Behavior Surveillance System

## (b) Smoking policies

5 studies investigate whether the anti-smoking programs, which have begun to accelerate in the early 1970s, have had the 'unintended consequence' of contributing to rising obesity, based on the medical evidence suggesting that "cigarettes can both suppress one's appetite and increase one's metabolism; therefore, a person who quits smoking may begin to consume more calories while expending fewer, leading to weight gain" (Courtemanche 2008: 2). Also, according to numerous studies, the fear of weight gain following smoking cessation discourages many smokers from even attempting to quit (Gruber and Frakes 2006:185). The anti-smoking program encompassed the levy of taxes, clean indoor air laws, and information.

Courtemanche examines the effect of cigarette taxes on body weight. His results provide evidence against the theory that the anti-smoking program has had the unintended consequence of contributing to the obesity epidemic as the anti-smoking program has actually had the unintended benefit of limiting this growth. However, Courtemanche is unable to determine the reason for the effects on food consumption and exercise, he hypothesizes that successfully quitting smoking leads to a newfound enthusiasm in one's health and improved confidence in one's ability to make healthy decisions.

It remains unclear whether the effects come from people quitting smoking, people smoking less, people not starting to smoke who would have if prices were lower, people who begin to make healthier decisions after their family and friends who quit smoking begin to make healthier decisions, or some combination of the four.

The results of Baum (2008) depend largely on a model specification. When more complete controls for correlation of cigarette taxes with state-specific time trends are added to the model, the results show that cigarette taxes significantly increase BMI and obesity risk. Baum finds that the effects are significantly larger for those with less income and those who are younger, potentially because they are more sensitive to cigarette costs. In addition, the time-lagged effects are significantly larger.

**Table 3** Data extraction table: Smoking policies

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Baum (2008)	BMI, obesity rate	self-reported	cigarette taxes	NLSY	randomly-chosen US youths (plus supplemental sample of minority and economically disadvantaged youths, plus military youths), excluding pregnant females and new mothers	9433 individuals with 102819 observations	1981-2002	US	positive	\$0.77 increase in cigarette taxes could increase BMI by approximately 0.6 units and obesity rate by approximately 3 percentage points.	Adjustment for bias in height and weight accruing from self-reporting. Results depend largely on a model specification.	1/8/0
Chou et al. (2004)	BMI, obesity rate	self-reported	cigarette price including taxes according to 'The Tax Burden on Tobacco 2002' by the Tobacco Institute  enacted clean indoor air laws (in private workplaces, government facilities, restaurants, other) according to the website for Disease Control and Prevention	BRFSS	nationally representative of the population 18 years of age and older at large	1111074 observations (cross-sectional)	1984-1999	US	positive effect of cigarette price  no (consistent) effect of clean indoor air laws	\$1 increase in cigarette price could increase BMI by approximately 0.5 units and obesity rate by approximately 3 percentage points.	Adjustment for bias in height and weight accruing from self-reporting.	1/7/0
Courtemanche (2008)	BMI, obesity rate	self-reported	cigarette taxes according to 'The Tax Burden on Tobacco 2004' by the Tobacco Institute	NLSY BRFSS	randomly-chosen US youths (plus supplemental sample of minority and economically disadvantaged youths, plus military youths) in NLSY  BRFSS Representative of the population 18 years of age and older at large	10739 individuals with 110800 observations in NLSY (cohort)  2385565 observations (cross-sectional) in BRFSS	1985-2004 in NLSY  1984-2005 in BRFSS	US	negative	\$1 increase in cigarette taxes could reduce average BMI by approximately 0.4 units and obesity rate by approximately 2 percentage points with a time lag of 6 years.	Results robust to a number of changes in model specification and data source (NLSY, BRFSS).	0/9/0
Gruber and Frakes (2006)	BMI, obesity rate	self-reported	cigarette taxes according to 'The Tax Burden on Tobacco 2002' by the Tobacco Institute	BRFSS	nationally representative of the population 18 years of age and older at large, excluding respondents over 65 years of age	1381248 observations (cross-sectional)	1984-2002	US	negative effect of cigarette taxes	\$1 increase in cigarette taxes could lower BMI by approximately 0.15 units and obesity rate by approximately 1.5 percentage points.	Analyze association with the same data source as Chou et al. (2004) but (i) excluding from the sample those over 65 years of age for health reasons, (ii) using more complete controls for time trends in smoking, and (iii) using cigarette tax rates rather than potentially endogenous cigarette prices.	2/6/0
Rashad et al. (2006)	BMI, obesity rate	measured in physical examination	cigarette taxes according to 'The Tax Burden on Tobacco 2002' by the Tobacco Institute  enacted clean indoor air laws (in private workplaces, government facilities, restaurants, other) according to the website for Disease Control and Prevention	NHANES	national samples of the population with some oversampling (indicated); restricted to adults 17 years of age and older	42003 (pooled sample of NHANES I, II and III)	1971-1994	US	positive effect of cigarette tax  no effect of clean indoor air laws	\$1 increase in cigarette taxes could increase BMI by approximately 0.06 BMI units and obesity rate by approximately 0.4 percentage points.		2/6/0

Baum, C. L. (2008). "The effects of cigarette costs on BMI and obesity." *Health Economics* 18(1): 3-19

Chou, S. Y., M. Grossman, et al. (2004). "An economic analysis of adult obesity: results from the Behavioral Risk Factor Surveillance System." *Journal of Health Economics* 23(3): 565-87

Courtemanche, C. (2008). "Rising cigarette prices and rising obesity: Coincidence or unintended consequence?" Working Paper

Gruber, J. and M. Frakes (2006). "Does falling smoking lead to rising obesity?" *Journal of Health Economics* 25(2): 183-197

Rashad, I., M. Grossman, et al. (2006). "The super size of America: An economic estimation of body mass index and obesity in adults." *Eastern Economic Journal* 32(1): 133-148

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

NLSY: National Longitudinal Survey of Youth  
BRFSS: Behavioral Risk Factor Surveillance System  
NHANES: National Health and Nutrition Examination Survey

Cigarette prices have not only been determined highly by taxes but also by the settlement of the tobacco lawsuits against cigarette makers to recover funds spent treating diseases related to smoking, which lead to cigarette makers "passing their losses on to loyal (i.e. addicted, price-inelastic) customers" (Courtemanche 2008:3). Thus, not only studies analyzing the cigarette tax are insightful for policy but also studies analyzing the relationship between cigarette price and overweight. Chou et al. (2004, 2006) estimate the effect of cigarette price and clean indoor air laws on BMI and obesity rates. The results indicate that increasing cigarette prices contributed to the obesity epidemic. The effects of the clean indoor air laws do not show a consistent pattern. This may reflect in part the endogeneity of these laws, i.e. the relationship reflects the underlying preferences of workers and employers rather than a direct causal process.

Rashad et al. (2006) also estimate the effect of cigarette taxes and clean indoor air laws on BMI and obesity risk. They found a positive effect of cigarette tax and no effect of clean indoor air laws.

Gruber and Frakes (2006) analyze the association between cigarette taxes and BMI and obesity rates using the same data source as Chou et al. (2004) with a number of modifications to the sample, to the model specification, and using cigarette tax instead of cigarette price. They find a negative effect of cigarette taxes on BMI and obesity risk. The analysis by Chou et al. was clearly not robust to the model specification changes conducted by Gruber and Frakes. Gruber and Frakes also point to the implausibly high effect estimates of cigarette taxes on the risk of being obese. They calculate that a \$1 increase in cigarette taxes implies that individuals who quit smoking are 56% less likely to be obese. Such a large effect, they conclude, is implausible in either direction. From the conflicting results in the literature, Gruber and Frakes conclude that there is no evidence for a large weight effect from smoking cessation in either direction.

**(c) Education policies**

The reasons for education to influence body weight status are manifold: “Education may cause better health in several ways. Education influences job opportunities and income, which in turn may influence health. Education may also enhance knowledge of how to live a healthy life, leading to improved choices of use of time and goods that affect health [...]. Moreover, just as education is believed to enhance market productivity, education may enhance health productivity [...].” (Arendt 2005:150).

**Table 4** Data extraction table: Education policies

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Arendt (2005)	BMI	self-reported	school reforms in 1958 and 1975: 1958: educational barriers for weaker students were lowered; increased number of lessons and school proximity in village schools for grades 8 to 10. 1975: minimum school-leaving-age was raised by increasing the compulsory years of education from 7 to 9 years; distinction between a vocational and a "normal" track during grades 8 to 10 was removed.	Danish National Work Environment Cohort Study WECS	sample seems representative of Danish workers	3258 individuals observed in both 1990 and 1995.	1990; 1995	Denmark	negative for 1958 reform no effect of 1975 reform		The school reforms are used as instruments for education. The 1958 was able to increase educational attainment, whereas the 1975 reform could not increase it.	0/9/0
Loureiro and Nayga (2005)	overweight rate, obesity rate	self-reported**	percentage of GDP dedicated to education	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	23 countries	1990-2002	OECD countries	negative	1% increase in GDP dedicated to education decreases the obesity rate by 2.4 percentage points. The effect on the overweight rate is not statistically significant.		2/6/0

Arendt, J. N. (2005). "Does education cause better health? A panel data analysis using school reforms for identification." *Economics of Education Review* 24(2): 149-160

Loureiro, M., L and R. M. Nayga (2005). "International dimensions of obesity and overweight related problems: An economics perspective." *American Journal of Agricultural Economics* 87(5): 1147-1153

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

\*\* Self-reported for all countries except Australia, Luxembourg, New Zealand, United Kingdom, and USA

Arendt (2005) uses a school reform as a quasi-experiment to assess the impact of education on BMI. Arendt shows that educational attainment jumped to a higher level in the years following the 1958 reform but not those following the 1975 reform. As a consequence, the 1958 reform with it increase in educational attainment was able to lower BMI.

Loureiro and Nayga (2005) analyze the effect of public spending in education (measured in percent of GDP) on overweight and obesity prevalence in OECD countries. They find that expenditures in education decrease the risk of obesity.

## (d) Environment policies

Loureiro and Nayga (2005) examine whether a country's environmental condition as a proxy for public policies that encourage high living standards affect overweight and obesity rates in OECD countries. For the indicator used, the total per capita volume of emissions, they are unable to find a consistent pattern.

Rashad et al. (2006) estimate the effect of gasoline taxes on BMI and obesity rates. Their hypothesis is that higher gasoline taxes may encourage people to walk or use public transportation rather than take the car, but that higher gasoline taxes may also influence eating pattern by making the purchase of healthy groceries or restaurant food more or less costly (depending on the proximity of such facilities). They did not find a consistent pattern. This result implies that people do not react to the disincentives of increased gasoline taxes or that the effects offset each other.

**Table 5** Data extraction table: Environment policies

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Loureiro and Nayga (2005)	overweight rate, obesity rate	self-reported**	per capita volume of emissions (as a proxy for public policies that encourage high living standards) according to 'OECD Environmental Data Compendium 2002', available at <a href="http://www.oecd.org">www.oecd.org</a>	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	23 countries	1990-2002	OECD countries	no effect			2/6/0
Rashad et al. (2006)	BMI, obesity rate	measured in physical examination	gasoline taxes according to 'Facts and Figures on Government Finance'	NHANES	national samples of the population with some oversampling (indicated); restricted to adults 17 years of age and older	42'003 (pooled sample of NHANES I, II and III)	1971-1994	US	no consistent pattern of effect of gasoline tax			2/6/0

Loureiro, M., L and R. M. Nayga (2005). "International dimensions of obesity and overweight related problems: An economics perspective." *American Journal of Agricultural Economics* 87(5): 1147-1153

Rashad, I., M. Grossman, et al. (2006). "The super size of America: An economic estimation of body mass index and obesity in adults." *Eastern Economic Journal* 32(1): 133-148

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

\*\* Self-reported for all countries except Australia, Luxembourg, New Zealand, United Kingdom, and USA

## (e) Food market regulations

Food market regulations that have been analyzed regarding their effect on body weight status include food taxes, subsidies on agricultural products and agriculture policies in general, as well as aspects relating to market entry ease and food content and labelling regulations.

### Food taxes and subsidies

Lakdawalla and Philipson (2001) examine how food taxation may impact BMI. They find that a higher food taxation (relative to the taxation of other goods) decreases the price of food (relative to other goods), and this decrease in the relative food price will increase BMI. For example, an increase in food tax of 2 to 3% relative to a tax of 7% on other goods results in an increase of the relative food tax of approximately 1%. This increase would lower the relative food price by 77%. A decrease of food prices

by 77% would increase BMI by approximately 0.4 units (own calculations). The impact of the relative food tax on the relative food price seems implausibly high, and the direction of the effect seems to be questionable. Lakdawalla and Philipson see two possible interpretations of this result: "First, lawmakers could exempt food from taxation when the demand for food is high. [...]. Second, lawmakers could exempt it from taxation when the supply price of food is high." (Lakdawalla and Philipson 2001:21). Either way, the estimates will then not indicate how BMI would change in response to a change in the relative food tax.

**Table 6** Data extraction table: Food taxes and subsidies

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Etilé (2008)	overweight rate	self-reported obesity rate	taxes and subsidies on	TNS WorldPanel household survey	randomly-chosen US youths (plus supplemental sample of minority and economically disadvantaged youths, plus military youths); data from surveys conducted before 1982 excluded so that every cohort member reached age 18.	21 407 observations (cross-sectional)	2001-2005	France	positive for subsidies on fruits and vegetables negative for taxes on soft drinks, pastries, desserts, snacks and ready-meals.	For example, a 10% tax and a 10% subsidy (scenario 5) would reduce the prevalence of adult obesity by 24%, i.e. from approximately 10.0% to 7.6%. The prevalence of overweight would decrease by roughly 15%, i.e. from 35.9% to 30.7%.		1/7/0
Lakdawalla and Philipson (2001)	BMI	self-reported	state taxation of food relative to other goods according to "Facts and Figures on Government Finance" Relative food tax is defined as (1+food tax) divided by (1+tax).	NLSY	randomly-chosen US youths (plus supplemental sample of minority and economically disadvantaged youths, plus military youths); data from surveys conducted before 1982 excluded so that every cohort member reached age 18.	not available	1982-1998	US	positive The estimates show that increases in the relative taxation of food lowers the relative supply price of food, and lower food prices increase BMI. Thus, increases in the relative taxation of food increases BMI.	For example, an increase in food tax of 2 to 3% relative to a tax of 7% on other goods results in an increase of the relative food tax of approximately 1%. This increase would lower the relative food prices by 77% (implausibly high). A decrease of food prices by 77% would increase BMI by approximately 0.4 units.	Adjustment for bias in height and weight accruing from self-reporting. Both the size and the direction of the effect of the relative food tax on relative food prices is surprising.	5/4/0
Schroeter et al. (2008)	body weight	measured in physical examination	tax on food away from home	NHES NHANES	national samples of the population with some oversampling (indicated);		1963/65 - 1999/2002	US	positive	A 10% tax on food away from home would increase the body weight by 0.196% ; or 0.170kg for an average man and 0.146kg for an average woman.	Estimate based on simulation.	5/3/0
Schroeter et al. (2008)	body weight	measured in physical examination	tax on caloric soft drinks	NHES NHANES	national samples of the population with some oversampling (indicated);		1963/65 - 1999/2002	US	negative	A 10% tax on regular soft drinks leads to a weight loss of 0.099% or 0.086kg for an average man and of 0.122% or 0.091kg for an average woman.	Estimate based on simulation.	5/3/0
Schroeter et al. (2008)	body weight	measured in physical examination	subsidy on fruit and vegetables	NHES NHANES	national samples of the population with some oversampling (indicated);		1963/65 - 1999/2002	US	positive	A 10% subsidy on fruit/vegetables would lead to a weight increase of 0.222% or 0.193kg for an average man and of 0.122% or 0.091kg for an average woman.	Estimate based on simulation.	5/3/0
Schroeter et al. (2008)	body weight	measured in physical examination	subsidy on diet soft drink	NHES NHANES	national samples of the population with some oversampling (indicated);		1963/65 - 1999/2002	US	negative	A 10% subsidy on diet soft drinks leads to a weight impact of -0.071%, or -0.061kg for the average man and -0.053kg for the average woman.	Estimate based on simulation.	5/3/0

Etilé, F. (2008). "Food price policies and the distribution of body mass index: Theory and empirical evidence from France." [PSE Working Paper Series No. 2008-28](#)

Lakdawalla, D. and T. Philipson (2002). "The growth of obesity and technological change: A theoretical and empirical examination." [NBER Working Paper Series No. 8946](#)

Schroeter, C., J. Lusk, et al. (2008). "Determining the impact of food price and income changes on body weight." [Journal of Health Economics](#) 27(1): 45-68

\* Scoring system: No/Yes/Uncler. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

\*\* Self-reported for all countries except Australia, Luxembourg, New Zealand, United Kingdom, and USA

NLSY National Longitudinal Survey of Youth  
NHANES National Health and Nutrition Examination Survey  
NHES National Health Examination Survey

Schroeter et al. (2008) simulate the impact that changes in taxes or subsidies for food and drinks would have on body weight. Schroeter et al. find that a tax on food away from home or a subsidy of vegetables and fruits would increase body weight while a tax on regular soft drinks or a subsidy of diet soft drinks would lower body weight. The result that an increase in the tax on food away from home would increase the body weight appears counter-intuitive. However, the tax on food away from home does in fact decrease away-from-home food consumption, but it increases at home food consumption (e.g. processed food) due to the fact that the two categories are substitutes. Because many of the foods consumed at home are energy-rich, total consumption actually increases.

Etilé (2008) estimates for French household survey data the impact of a 10% price decrease in fruits and vegetables on body weight and the impact of a 10% price increase in soft drinks, pastries, deserts, snacks and ready-meals on body weight. He then simulates the impact of five policy scenarios (taxes and subsidies) on the overweight and obesity prevalence. The authors find that with every of the five policy scenarios the distribution of BMI in the population is clearly more favourable in a public-health sense.

## Agricultural policies

Loureiro and Nayga (2005) estimate the effect of consumer support for the agricultural sector on overweight and obesity prevalence in OECD countries. They find that countries have a lower overweight and obesity prevalence the higher the contributions from consumers (via higher agricultural prices) they require.

**Table 7** Data extraction table: Agricultural policies

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Cutler et al. (2003)	obesity rate	self-reported**	frequency of price controls according to 'Economic Freedom of the World Index' (average of 1989-1994)	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	21 countries		OECD countries	negative	A one standard deviation increase in price controls associated with about 3.7 percentage points less obesity across OECD countries.	The Economic Freedom of the World Index ranges from 0 to 10. Cutler et al. normalized it to have a mean of 0 and a standard deviation of 1.	2/6/0
Cutler et al. (2003)	obesity rate	self-reported**	producer protection (ratio of agricultural prices in the country to worldwide prices; the measure captures tariff and nontariff barriers to agriculture) according to 'Producer and Consumer Support Estimates OECD Database', available at <a href="http://www.oecd.org">www.oecd.org</a>	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	9 countries		OECD countries	negative	A one standard deviation increase in domestic prices above world prices reduces obesity by 4.5 percentage points across OECD countries.	The measure for producer protection is only available for 9 countries. The association between the measure for producer protection and obesity is possibly driven by pure price effects. The authors point out that the strong correlation between the measure of protectionism and other measures of regulation suggest that price effects are not the whole story.	2/6/0
Loureiro and Nayga (2005)	overweight rate, obesity rate	self-reported**	CSE (consumer support estimate) as a proxy for protective agricultural policies according to the 'Producer and Consumer Support Estimates OECD Database', available at <a href="http://www.oecd.org">www.oecd.org</a> ; the CSE is defined by OECD as 'an indicator of the annual monetary value of gross transfers from consumers of agricultural commodities arising from policy measures which support agriculture'. Authors use consumer support in percent of total volume of support.	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	23 countries	1990-2002	OECD countries	negative	1 percentage point increase in the percentage of CSE in percent of total volume of support decreases the overweight rate by 0.06 percentage points and obesity rate by 0.12 percentage points.	Usually, the CSE is negative, showing that the transfer from consumers is equivalent to a tax on agricultural commodities. In their application, Loureiro and Nayga facilitate the interpretation of the results by multiplying the CSE by 1. Thus, the higher the CSE, the greater the transfers from consumers to the agricultural sector via higher food prices.	2/6/0

Cutler, D., E. Glaeser, et al. (2003). "Why have Americans become more obese?" *Journal of Economic Perspectives* 17(3): 93-118

Loureiro, M., L and R. M. Nayga (2005). "International dimensions of obesity and overweight related problems: An economics perspective." *American Journal of Agricultural Economics* 87(5): 1147-1153

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

\*\* Self-reported for all countries except Australia, Luxembourg, New Zealand, United Kingdom, and USA

Cutler et al. (2003) examine the association between the obesity rate and (i) the ratio of agricultural prices in the country to worldwide prices (capturing tariff and non-tariff barriers to agriculture) as a measure of producer protection and (ii) the frequency of price controls across OECD countries. Both determinants are found to be negatively associated with obesity rates across OECD countries. The higher the frequency of price controls the less likely people are obese. According to economic theory this suggests that price controls are most likely to be price floors (and not price ceilings), thereby artificially increasing market prices which reduces consumption. Likewise,



the higher the ratio of agricultural prices in the country to worldwide prices, i.e. the higher the producer protection, the lower the obesity risk. Unfortunately, the available data for the determinant is restricted to 21 for the frequency of price controls and to 9 for the measure of producer protection. This places the results on a rather weak foundation.

### Market entry ease

Cutler et al. (2003) examine the association between the obesity rate in OECD countries and market entry ease (in days required to open a new business) as a measure of technology importation. The determinant is found to be negatively associated with obesity rates across OECD countries. The longer it takes the less easy it is to import new technology and the less “exposed” will individuals be to new processed foods and labour-saving devices. Unfortunately, the available data for the determinant is restricted to 22 observations, which places the results on a weak foundation.

Bleich et al. (2008) estimate the impact of market entry ease on body weight. They measure market entry ease on a scale of 0 to 10, where low scores signify that countries have regulations which retard entry into the market place. They assume that food is more available where it is easier for new businesses to enter into the market-place. Their results show that the more difficult market entry due to regulations the lower is the obesity rates across OECD countries.

**Table 8** Data extraction table: Market entry ease

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Bleich et al. (2008)	body weight	self-reported**	market entry ease (the ease with which new businesses can enter the market place) according to the “Economic Freedom of the World Index” (average of 1989-1994)	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	22 countries	1978-2002	OECD countries	negative	An average person would lose approximately 3.6 pounds if entry into the market place was retarded by 20 percent.	Authors control for self-reported BMI in their analysis. Estimations are based on measures of caloric intake and expenditure. By means of a Monte Carlo simulation they estimate the resulting impact on body weight.	1/7/0
Cutler et al. (2003)	obesity rate	self-reported**	time required in days to open a new business (as a measure of technology importation) according to “The Regulation of Entry”, 2002 by Djankov, La Porta, Lopez-de-Silanes and Shleifer	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	22 countries		OECD countries	negative	A 10 percentage increase in the number of days required to open a business reduces obesity by 0.26 percentage points across OECD countries.		2/6/0

Bleich, S., D. M. Cutler, et al. (2008). “Why is the developed world obese?” *NBER Working Paper Series* No. 12954

Cutler, D., E. Glaeser, et al. (2003). “Why have Americans become more obese?” *Journal of Economic Perspectives* 17(3): 93-118

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

\*\* Self-reported for all countries except Australia, Luxembourg, New Zealand, United Kingdom, and USA

### Food regulations (part of market entry ease)

Cutler et al. (2003) examine the association between obesity rates and the number of food statutes listed (including packaging, labelling requirements, preservative tolerances, and pesticide regulations) across OECD countries. The authors expected that in countries with more restrictive policies access to food would be more restricted which would lead to lower obesity prevalence. Cutler et al. find a negative association between the number of food statutes listed and the obesity rate across OECD coun-

tries. Unfortunately, data for the determinant is only available for 9 OECD countries. Thus, the results of the analysis are based on a weak foundation.

Variyam and Cawley (2006) examined the impact of the NLEA on BMI among American adults. “The NLEA [Nutritional Labeling and Education Act of 1990], which took effect in 1994, made labeling mandatory for most processed foods. It requires manufacturers of packaged foods to display the Nutrition Facts panel, which lists in a standardized format the amount of key macronutrients, vitamins, and minerals contained per serving. The NLEA also requires manufacturers to use specified serving sizes within product categories, declare nutrients as a percent of the recommended Daily Value, and use approved health and nutrient content claims”. (Variyam and Cawley 2006:1). The authors compared the change in body weight of label users over the pre/post-NLEA period with the change in body weight of label non-users over the same period. NHIS respondents are not randomized into the treatment group (label users) or control group (label nonusers), but rather they self-select into these groups. Therefore, label users and nonusers are likely to have different characteristics. In fact, label users had greater body weight compared with label nonusers in the pre-NLEA period. This is likely because, at any given time, heavier persons may be using labels in their attempt to lose weight. For this reason, differences in weight status between label users and nonusers at any given time cannot be used to draw inference on the efficacy of the labels. Instead, the change in weight status of label users and nonusers and the difference between these changes indicates the effect of the NLEA. These difference-in-difference estimations show that label-reading non-hispanic white women benefit from the new food labels, but the effect is insignificant for the rest of the race/gender groups or the overall population.

**Table 9** Data extraction table: Food regulations

Reference	Outcome indicator		Determinants	Study population					Results			Quality score*
				Data source	Sample	Sample size	Time frame	Country	Direction of effect	Quantity of effect	Notes	
Cutler et al. (2003)	obesity rate	self-reported**	number of food statutes listed (including packaging, labeling requirements, preservative regulations, and pesticide regulations) according to "International Food Law", 2000, edited by Kellam, Utz and Guarino	OECD Health Statistics	representative for OECD countries; representativeness on country-level depends on country surveys	9 countries		OECD countries	negative	A one standard deviation increase in the number of food statutes reduces obesity by 7.4 percentage points across OECD countries.	The measure is only available for 9 countries.	2/5/0
Variyam and Cawley (2006)	BMI	self-reported	Nutrition Labeling and Education Act (NLEA) (1990) taking effect in 1994	NHIS	respondents aged 18 and older out of a US representative sample; excluding individuals who indicate that they do not buy food	84760 (pooled sample pre-NLEA, i.e. 1991,1993) 49757 (pooled sample post-NLEA, i.e. 1995, 1998)	1991 and 1993 (pre NLEA); 1995 and 1998 (post NLEA)	US	negative (only for non-hispanic white women)	The introduction of the label lowered the average BMI of non-hispanic white women by 0.3 units.		0/8/0

Cutler, D., E. Glaeser, et al. (2003). "Why have Americans become more obese?" *Journal of Economic Perspectives* 17(3): 93-118

Variyam, J. N. and J. Cawley (2006). "Nutrition labels and obesity." *NBER Working Paper Series* No. W11956

\* Scoring system: No/Yes/Unclear. If score does not add up to 9 (according to 9 checklist items) it is because the remaining items are not relevant to the case

\*\* Self-reported for all countries except Australia, Luxembourg, New Zealand, United Kingdom, and USA

NHIS National Health Interview Survey

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## 6 Discussion

In this section we state the principal findings of the review and critically discuss their meaning. We begin with an appraisal of the findings as summarized in the thematic map (Table 1, page 45) and then continue with the in-depth review. We finish the chapter with a discussion of the strengths and limitations of this review. Building on this, the next chapter we will draw policy recommendations.

### 6.1 Discussion of thematic map

It seems that everyone knows why people gain weight: by eating too much and/or exercising too little. According to estimations, a consistently occurring energy imbalance of as little as 100 kilocalories per day may have caused the population-wide obesity epidemic (Hill et al. 2003; WHO 2000:105). This review aimed at looking behind the scenes to find out why large proportions of the population suddenly arrived at an energy imbalance.<sup>32</sup>

The systematic literature search has produced a large number of studies (677).<sup>33</sup> Even before analyzing the results of these numerous studies, the sheer number, the underlying time and effort required to produce them, and the significance given to the topic in the academic world hints at the relevance of the environment as a determinant of obesity. Also, the variety of factors studied provides an indication of the multi-faceted nature of obesity. A myriad of factors can theoretically influence individual decisions and behaviour and thereby give rise to a positive energy balance.<sup>34</sup>

Naturally, for policy reasons one would like to know which factors are most relevant or most prominently discussed. The kind of factors in the environment examined in these studies varies greatly. Therefore, we attempted to structure the factors analyzed in the 677 studies. The environment is structured in the domains of politics & law, economics, society & culture, technology, the physical & natural environment and policy (according to the PESTEL framework). Applying this PESTEL-framework to the case of obesity, we assigned the factors of the 677 studies to the different domains. Research has been active in all domains of the environment. Judging from that, there does not seem to be changes in a single, obvious domain that can be made responsible for the obesity epidemic. Instead, all domains seem to be somehow accountable, even the policy domain itself. Thereby, any change in these domains may cause a tip in the energy balance. In addition to assigning the factors of

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<sup>32</sup> Further, a large strand of literature analyzes the empirical association between factors in our environment and surroundings and physical activity and nutrition. Changes in physical activity and nutrition are the causes of an energy imbalance. However, analyzed in isolation, they allow no inference on the energy balance itself. Therefore, these studies are not considered here.

<sup>33</sup> 359, if studies solely analyzing the association between body weight status and some indicator for socioeconomic status (income, education, etc.) are excluded.

<sup>34</sup> See Swinburn et al. (1999:565-567), Booth et al. (2001) and French et al. (2001) for even more environment attributes that may be associated with overweight and obesity.

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the 677 studies to the 6 domains of the environment we studied the theories or hypotheses underlying the examined associations. Very quickly it became clear that in the context of obesity, the boundaries between these domains are not clear-cut and that the domains are strongly interlinked and interdependent.

From this we conclude that rather than a single, strong determinant it has been the interaction of a multitude of factors and changes in the environment that have contributed to the obesity epidemic. For example, technological progress (automation, television, cars, etc.), availability of fast food and sugar-sweetened soft drinks, reductions in job strenuousness and changes in the occupational structure, commuting patterns, etc. were there before the start of the obesity epidemic in 1980, making it unlikely that one of these factors in isolation could be driving the trend. Moreover, with the general level of education and SES having increased over the past 30 years, some classical determinants of health have continuously been strengthened. Nevertheless, we have experienced steep increases in obesity prevalence during the same period. This is explained by the fact, that education and SES are – however important – just two of a number of important factors. While some health promoting factors have been strengthened, other tendencies counteract and make the effect disappear. Thus, it seems that the influence of a single factor in the environment on obesity is at best small. Moreover, the changes in the environment have been gradual, making it difficult to explain the steep rise in obesity prevalence.

Over and above it, it has been the simultaneous surge of all these changes that have contributed to obesity rates increasing so suddenly and steeply. While individuals learn to adapt to gradual changes, the abruptness of changes and the accumulation of changes in the environment seem to overstrain their capacities. Similar experiences are witnessed in the Eastern European countries which after the collapse of the communism were exposed to innumerable changes through the market transition, globalization, westernization and urbanization. The market transition in Eastern European countries mirrors the transition which the industrialized world has experienced in the past several decades, in short form.

In addition to structuring the existing 677 studies according to the domain of the environment, we differentiate between three levels of the environment: the micro-level environment, the meso-level environment and the macro-level environment. Among other, these levels characterize the proximity of the factors to the individual, which also influences the degree to which it is amenable to the control of individuals.<sup>35</sup> We analyzed whether there is a substantial clustering of studies on a given level of the environment. There is no such clear clustering as the thematic map has shown (see Figure 6). The large number of studies analyzed on the macro-level indicates that there is some concern with the obesogenic on that level. This may have serious implications. If factors on the macro-level environment are obesogenic, it is difficult to

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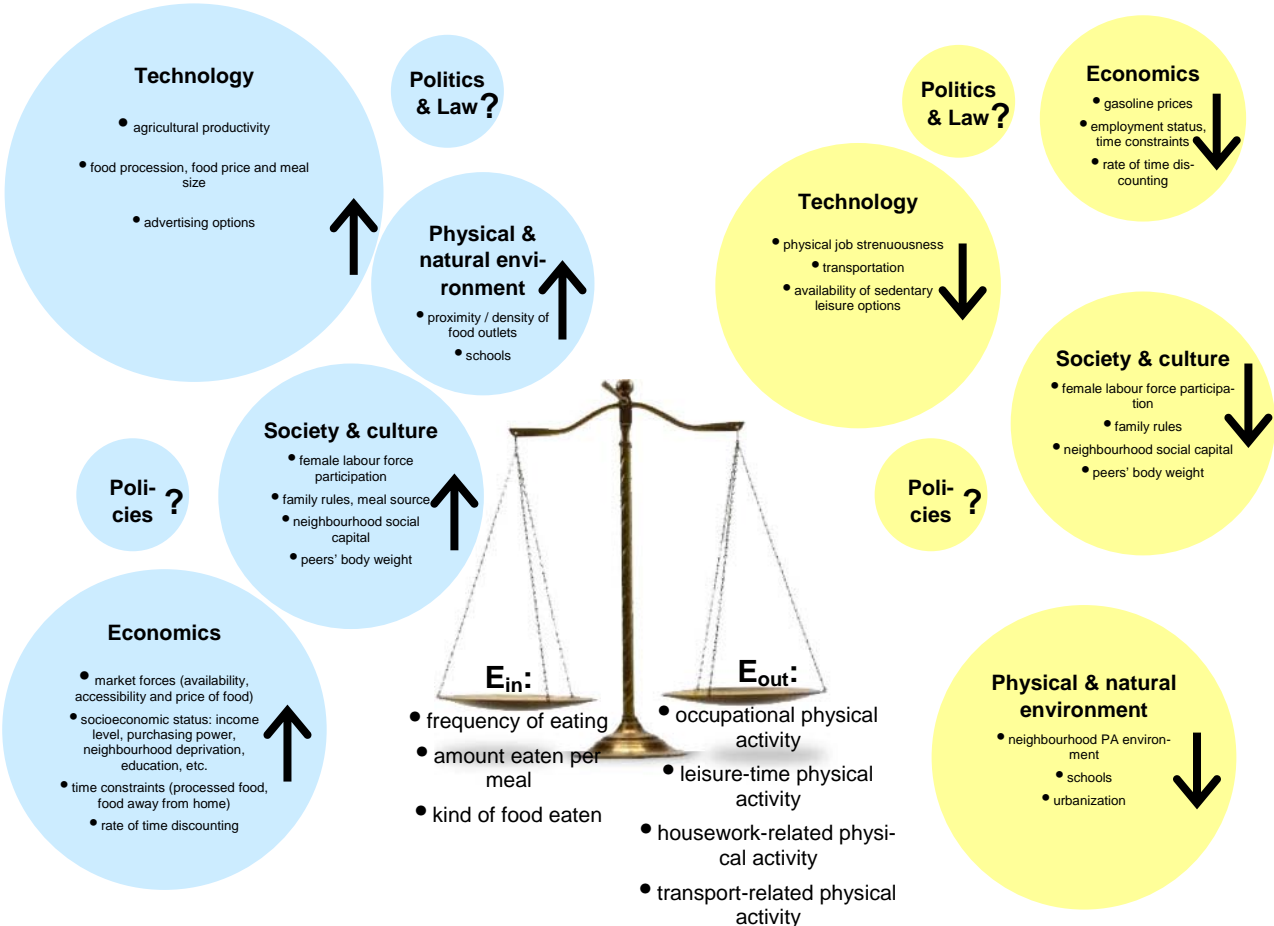
<sup>35</sup> For example, an individual may not be able to influence state regulations regarding school food or physical education requirements, but an individual can buy healthy food for the home or choose to live in a neighbourhood with good possibilities for physical exercise. Clearly, this argument is only partially apposite because even on the environment's micro-level, economic restraints, for example, can defy the control over the immediate environment.

expect individuals to control their weight in a land of milk and honey since these factors are those that are essentially not under the control of individuals. Under such circumstances, health promotion programmes aimed at improving individual behaviour can be expected to have only a limited effect.

Another noteworthy point accrues from the substantial strand of literature relating to factors in the meso-level physical & natural environment, in particular the neighbourhood environment. The increasing call for environmental sustainability should lead into the same direction as the efforts of the public health departments concerning more active transportation, reduction in urban sprawl, etc. It can be expected that the pursuit of parallel objectives is helpful in yielding results. So far, no studies were found evaluating the impact of neighbourhood environment policies on body weight status of residents, though. There are a number of studies evaluating the impact of neighbourhood redesign on physical activity behaviour, though.

Figure 8 visualizes the results from the thematic map regarding the impact of the environment on the overweight outcome, with  $E_{in}$  being energy intake and  $E_{out}$  being energy expenditure. The relative weights as perceived by the extent of research published and the plausibility of the underlying hypotheses are illustrated by the size of the globes.

**Figure 8** Impact of the environment on obesity as perceived by review



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As an overview, figure 8 illustrates that according to the amount of research published and according to the plausibility of the underlying hypotheses the trend in the past 30 years has been that the factors in the environment have encouraged energy intake and discouraged energy expenditure.<sup>36</sup> In other words, the environment has contributed to the obesity epidemic by facilitating forms of behaviour that result in a positive energy balance (meaning that energy intake > energy expenditure). All environment domains affect both energy intake and energy expenditure. There is a lively debate going on regarding whether the obesity epidemic is primarily caused by declining physical activity or by increasing energy intake (Bleich et al. 2008; Jeffery and Harnack 2007; Sturm 2005a; Sturm 2005b). It is argued that resolving this energy intake-expenditure split is important in deciding whether policy interventions should focus on food intake or physical activity. In our opinion this review demonstrates that this debate is not a very relevant one because all domains, through their interlinked dependencies, concern both food intake and physical expenditure, and are thus important to improve the energy balance.

A further important insight from this review is that the obesity epidemic can plausibly be traced back to environment factors that are essentially the results of long-run improvements to enhance individual or social welfare. Among those are the increased availability and affordability of food for everyone; the widespread computer use; increased participation of women in the labour force; the decrease in physical job strenuousness through automation; the possibilities of passive transportation; the anti-smoking policies; etc.

Thus, the obesity epidemic is part and parcel of some developments which we cannot and maybe should not try to stop or reverse. Instead, policy makers are challenged to find innovative ways to mitigate the influence of the environment on individuals and offer opportunities so that everyone can handle the obesogenic environment. Moreover, the thematic map may help to identify resources in our environment that may be leveraged without there being a conflict with aspects of life other than health such as progress, comfort, security, etc. In particular, the following leverage points could be looked into:

- Providers of food to be consumed outside the home, who have been implicated as an aspect of the obesogenic environment, can also become an important venue for initiatives to improve dietary intake (e.g. workplaces, schools, nurseries, businesses, etc.)
- Options for physical activity in leisure time must be improved for children, and especially forms of organized physical activity that can accommodate the needs of children whose both parents participate in the labour force

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<sup>36</sup> A much more sophisticated but less concise figure on the causal linkages between environment factors and the body weight is presented by Butland et al. (2007) in their system map. Their system map confirms the complex nature of the obesity issue with the large number of variables and many causal linkages accounted for in the map.

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- Design of neighbourhoods and transportation routes need to be in accord with the recommendations given for an environment that promotes not only leisure-time physical activity but also active transportation and sustainability.
  - The social multiplier effect, which in connection with the increasing obesity rates has been associated with a clustering of obesity among peers and families, may be sought to be turned into a positive externality. Favourable health habits may be generated and multiplied more easily among members of families and in social networks. Thereby, exploiting the “social multiplier” effect may produce faster reductions in overweight and obesity rates.
  - Given the complex interdependencies of the large number of variables and the many causal linkages it may make sense to re-evaluate existing policies (from different fields such as agriculture, health, market regulations, social security, etc.) to assess whether they might bring forth unintended consequences and provide disincentives for weight-related behaviour.

Over and above this, in view of the substantial inequalities regarding the distribution of obesity across social groups it is important that all groups in the society are equipped with the possibilities and given the opportunities to handle the obesogenic environments.

As an important conclusion from the thematic map as constructed in this literature review is the need for an integrated approach to try to fight the obesity epidemic. Policy makers need to coordinate their goals and activities with businesses, schools and communities as intervention in just one area may precipitate compensatory changes elsewhere that dampen the effect. It is not only the individuals and the government who are interested in reversing the obesity epidemic but also the private sector and other stakeholders, for example because healthy individuals are more productive. A multi-stakeholder approach is seen as the most sensible way forward as no party is in a position to meaningfully reduce the size of the obesity problem without full cooperation with other stakeholder. Moreover, policy makers from different federal agencies with their different mandates need to coordinate: The interdependencies in the thematic map highlight the need to consider policies in many sectors, including education, transport, social security, agriculture, media and finance (Lobstein and Millstone 2007:12). It is important that all agents align their goals, parallel their activities and avoid courses of action that are made futile by countering or conflicting activities.

## **6.2 Discussion in-depth review of policy measures**

In the in-depth review studies analyzing the association between body weight status and some measure belonging to policy domain of the environment are examined. The policy measures of the 14 studies relate to PE requirement law, smoking policies, education policies, environment policies and food market regulations.

Table 1 shows the distribution of the 14 studies into the different policy domains and the intervention/policy that was examined. The last column indicates the effect of the intervention or the policy on BMI found by the studies. The last column can be interpreted as an association between the intervention/policy and BMI. ‘Lower’ means

that if there is more of the indicated intervention/policy then BMI tends to be lower and vice versa. For example in the case of agricultural policies more food market regulation seems to be associated with a lower BMI meaning that less food market regulation would mean a higher BMI (all other things being equal).

**Table 1 Overview over 14 studies found of policy measures**

Policy domain	Number of studies / indicators	Intervention / policy	Effect on BMI
Physical education	1/1	PE requirement	No effect
Smoking policies	5/5	Higher cigarette tax	3 higher / 2 lower
Education policies	2/2	Various / GDP spending on edu	1 no effect / 1 lower
Environment policies	2/2	Emissions / gasoline taxes	No effect
Food market regulations	3/6	Food taxes and subsidies	3 higher / 3 lower
	2/3	Agricultural policies	3 lower
	2/2	Market entry barriers	2 lower
	2/2	Food regulation	2 lower

In the following we will discuss the evidence found in the studies of each of these five policy fields. Each paragraph begins with a very brief summary of the main results described in detail in paragraph 5.3 and summarized in table 1.

**6.2.1 Physical education requirement law**

The one study found analyzed whether PE requirement laws had an effect on high school students’ body weight status in the USA. The study took advantage of the fact that the introduction of the law generated a quasi-natural experiment, which as a study design is generally superior to assess causality. No statistically significant effect was found on either BMI or the risk of overweight.

This result may give an indication of how complex the determination of body weight is. Even with the help of a quite sophisticated study design the expected effect of increased PE requirements holds off. The determinants of body weight being so varied and so interlinked, an isolated policy measure may still produce no effect. A possible explanation is that schools fail to comply with the law or their PE classes do little to actually promote physical activity. Also, there may be compensating or offsetting behaviour through students (snacking more because of PE, or decreasing exercise outside of school in response to increased exercise during school). However, the results stem from one study, and as such they are not to be overvalued regarding the generalisability. An insight from this study is that macro-level policies require an inte-



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grated approach and policy makers need to coordinate with all schools, communities, businesses and other agents from other policy fields.

### **6.2.2 Smoking policies**

Five studies investigate whether the anti-smoking programs beginning in the early 1970s may have contributed unintentionally to rising obesity rates.

The five studies use three different population surveys to examine the effects of cigarette taxes, total cigarette prices and clean indoor laws on obesity rates. Different specifications of their estimation models yield very inconsistent results. Depending on the model specification, taxes and cigarette prices are both shown to have a significant impact on obesity and that they do not. Likewise, two studies found no statistical evidence for an impact of clean indoor laws on obesity rates.

Contrary to what is thought to be 'common knowledge', the smoking policies may have led people to quit smoking but quitting smoking has not systematically caused increases in BMI.

A further insight from these studies is that estimating the impact of macro-level policies on the body weight status on the population level is associated with substantial uncertainty. The same databases can produce opposite results, depending on model and variable specifications.

### **6.2.3 Education policies**

The reasons for education to influence body weight status are manifold. Education influences job opportunities and income, which in turn may influence health, or education may also enhance health competence, which leads to healthier choices being made.

Many studies report an overall socioeconomic gradient in obesity in modern industrialised societies. Obesity rates tend to decrease progressively with increasing SES, whether the latter is measured by income, education, or occupation-based social class. Recent research has shown that the gradient is stronger for women than for men (Sánchez-Vaznaugh et al.). One study of the in-depth review examined whether there is an association between public spending in education and obesity prevalence in OECD countries. They find that expenditures in education do in fact decrease the risk of obesity. Another study used a school reform, which was shown to increase the educational attainment, as a quasi-experiment to assess the impact of increasing education on BMI. The experiment showed that in response, there was a reduction in BMI. The quasi-experimental study design implies that some of this reduction is causal. In general, there seems to be quite robust evidence that there is a significant association between education and body weight status. However, the evidence gives no indication whether education influences health via income or via health competence.

Regarding education increasing income and thereby reducing obesity, there is a strand of literature assessing the effect of income support policies (e.g. US Food

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Stamp Program) on overweight and obesity risk. These studies are listed under the micro-level environment of the policy domain.

With respect to education increasing health competence and thereby reducing obesity, obesity could be explained by a lack of credible nutritional information on the nutritional value of food, or information on the health consequences. The debates evolve around the following points: Consumers generally have less information about the calorie content of foods they eat away from home (Cawley 2006). The increasing trend of consuming food away from home and pre-processed food results in consumers having less and less information about what they take in. Closely connected to this is the demand for nutrition labelling. Nutrition labels are a way to provide the consumer with standardized and comprehensible information and make this information easily accessible. Two studies analyze the association between body weight status and the number of food statutes in OECD countries and the nutrition labelling requirements as a specific form of market entry barriers. More restrictive countries (in terms of higher number of food statutes) are shown to exhibit lower BMI in the population. The result of this analysis is based on 9 observations and is therefore built on a weak foundation. The introduction of the nutrition labelling requirement NLEA [Nutritional Labeling and Education Act of 1990], which took effect in 1994 and made labelling mandatory for most processed foods is shown to have decreased BMI among white females, though only for that specific population group and not for others. The NLEA created a quasi-experimental situation. The results are therefore based on a relatively valid foundation.

A difficulty of nutrition labels is to make sure that consumers understand and critically judge nutritional information that is based on % daily value, or that refers to a portion size which is smaller than the entire food pack. A different issue are food labels such as “diet”, “light”, “fat-free”, etc. Such health claims may lead individuals to make suboptimal decisions if they are misled to derive that “fat-free” equals “low on calories” or “healthy” and vice versa (so called “halo effect” of food labels). Moreover, it has been shown that such food labels may bring forward a compensating behaviour by increasing consumption of the products (Jeitschko and Pecchenino 2006:443; Wansink 2006). A further issue is marketing. Marketing transmits information about the product, but generally not in a standardized, regulated way. Therefore, marketing, in particular if it is directed at children, is increasingly subject to regulation.<sup>37</sup>

The insight gained in the field of health competence and education is that reducing the cost and effort to obtain information may allow consumers to adjust more swiftly to new circumstances. Especially in view of the dynamic food market, the increasing reliance on food away from home or processed foods may overstrain the capabilities of people to acquire the information needed for an optimal decision and make the provision of easily accessible, straightforward information central. However, not all individuals use nutrition labels to access information about the product equally. In

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<sup>37</sup> Three WHO reports by Hawkes systematically review the regulatory environment surrounding the marketing of food to children, nutrition labelling and health claims in over 70 countries (Hawkes 2004a; Hawkes 2004b), with a subsequent update examining the changes in the regulatory environment around food marketing to children since 2004 (Hawkes 2007).

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fact, it has been shown that the use depends on certain characteristics such as income, educational attainment, etc. Therefore, restricting policy to information will very likely increase instead of reduce the distributional inequalities observed in obesity rates.

#### **6.2.4 Environment policies**

One study examined whether there is an association between obesity rates in OECD countries and the total per capital volume of emission, based on the assumption that low emissions would serve as a proxy for public policies that encourage high living standards in general. They are unable to find a consistent pattern.

Another study estimates the effect of gasoline taxes on BMI and obesity rates. They did not find a consistent pattern. Assuming that the gasoline taxes are in fact large enough to provide an economic incentive for more active transportation or the consumption of local or home-made foods, we would in fact expect an effect on body weight status, similar to the case of the increased PE requirement law above. The insight gained there is underlined here: macro-level policies require an integrated, coordinated approach. Isolated measures will leave no visible mark.

Another insight gained here is that policies from other fields may not only offset the public health efforts but may also provide support. The goals of different government departments may in fact be parallel, as seen here in the fields of environmental sustainability and public health.

#### **6.2.5 Food market regulations**

Food market regulations that have been analyzed regarding their effect on body weight status include food taxes, subsidies on agricultural products and agriculture policies in general, as well as aspects relating to market entry ease and food content and labelling regulations.

##### *Food taxes and subsidies*

The three studies analyzing the association between taxes or subsidies and body weight status arrive at ambiguous results. Taxes on unhealthy food should theoretically result in higher product prices, where higher product prices are a disincentive for consumption. Therefore, it is expected that taxing unhealthy food lowers BMI. Subsidizing healthy food should analogically result in lower BMI as well. This pattern was found in only about half of the estimations. The effect of taxes on obesity rates thus seems not as straightforward as it would be expected from theory. Again, many other factors may play an important role, and if they are not considered, the expected effect may hold off. For example, taxing food consumed away from home increased BMI in one study. This is compatible with theory only if the food eaten at home is healthier than the food eaten away from home. This may in fact be the case if food eaten at home is primarily processed food.

The practical implementation of a tax or a subsidy is associated with various difficulties. What products or ingredients should be taxed? Taxing ingredients such as fat and sugar is critical as a healthy nutrition includes some fat and sugar. Taxing junk

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food or fast food involves the difficulty of definition. Anecdotal evidence from Britain shows just how difficult that is. A court ruled in 2008 that Pringles are not considered potato chips and as such they are not to be subject to the value added tax VAT which is applicable for potato chips but not other foods.<sup>38</sup>

Another disadvantage of a tax on certain food is the regressive character of the tax, meaning that individuals with low income will bear a higher burden of the tax, measured as a proportion of their income.

One advantage of a tax is that it generates revenue for the government which could be used to finance public health programmes. A subsidy, on the other hand, requires financing through the government. Another advantage is that not only may a tax make consumers switch from unhealthy food purchases to more healthful alternatives, but the tax could also provide an important financial incentive for food manufacturers and fast-food restaurants to revise the nutritional content of their foods.

### *Agricultural policies*

2 studies assessed the impact of agricultural policies (such as producer protection, consumer support via higher prices paid for agricultural products, etc.) on obesity in OECD countries, with the same datasets. They both arrive at the same results: agricultural policies reduce the prevalence of overweight and obesity via prices of agricultural produce that are above market price.

The validity of these results is somewhat weakened by the fact that the database of the employed OECD health statistics contains very few observations (21 or 9, respectively), which is generally too small a sample for sound statistical analyses.

One interesting insight from these studies is that policies which have been implemented decades ago to support and secure the supply in an uncertain environment, serve as incentives or disincentives which influence people's body weight status.

Another important insight is that these policies will not only affect the products that are directly targeted with the policy but also all the goods that are produced with them. A famous example is the heavily subsidisation of corn in the USA. The price for corn is low thanks to the subsidies, which allows the producers of soft drinks and snacks to sweeten their products inexpensively with corn syrup. As a result, not just the corn but also the soft drinks and snacks will be relatively cheap.

### *Market entry ease and food regulations*

2 studies estimated the association between market entry ease (measured in days required to open a new business and in regulations which retard market entry) and the risk of overweight and obesity across OECD countries. Both studies arrive at the result that the more difficult market entry is the lower is the obesity rate. This implies that the slower new ideas, products, or technology is introduced in a country, the less likely the residents are to become overweight. This may be because delays in admitting new products etc. to a market may give people a better possibility to get informed and adapt to the new situation. According results were found in the two stud-

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<sup>38</sup> See article on <http://news.bbc.co.uk/1/hi/business/7490346.stm>

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ies analyzing the effect of the number of food statutes in OECD countries and the nutrition labelling requirements. Alternatively, the results may also be driven through a connection to agricultural policies, with more liberal markets having both less market entry barriers and less agricultural policies.

## **6.3 Strengths and limitations of this review**

### **6.3.1 The thematic map**

The strength of the review certainly lies in its comprehensiveness. This comprehensiveness is a result of (i) searching a wide array of databases relating to medical, economic and social sciences, and using additional sources, (ii) applying a relatively broad concept of the environment and thus accounting for a diversity of incentives and disincentives for healthy behaviour, (iii) including discussion papers that have not (yet) been published in journals or books, (iv) considering not only studies written in English but also in French, German, Italian, and Spanish, and (v) defining a long time-frame, from 1980 to 2008 (mid-year). Due to the comprehensiveness and the interdisciplinary approach of the review search we judge the review findings to be highly valid and inclusive of the existing literature concerning the review question. By including discussion papers that have not been published in journals or books we were able to substantially reduce the risk of publication bias and thereby increase the validity of the review findings.<sup>39</sup> Naturally, we can never rule out having overlooked important evidence. However, a bias toward publication of significant results only is unlikely, as is demonstrated by the in-depth review with its good number of reported non-associations.

The systematic literature search has produced a large number of relevant studies (677)<sup>40</sup> that examine the empirical association between body weight status and factors in our environment and surroundings. The key common denominator of all those studies is that the environment is seen as providing incentives and disincentives for human behaviour, and therefore the environment or system is directly associated with the energy imbalance. Due to this very large number of studies found through the literature search it was impossible to conduct a systematic data extraction and analysis of all the study results. Therefore, we are unable to compare detailed study results and draw conclusions from the actual effects found in studies, and to discuss whether and to what extent the associations and cause-effect relationships are actually empirically established. In view of the known difficulties involved in assessing causality between environmental factors and the obesity risk (e.g. lack of data, time-lag, influence of context, scarcity of quasi-experimental data, uncertainty regarding

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<sup>39</sup> As is characteristic of systematic reviews in general, we were only able to identify what has been published, instead of what has not been published. The fact that studies, which do not prove what has been expected by researchers (or funding parties), are less likely to get published introduces systematic bias, known as 'publication bias'. Hence, studies that report favourable results are overrepresented and there is a tendency for overestimation of the effects by reviews.

<sup>40</sup> 359, if studies solely analyzing the association between body weight status and some indicator for socioeconomic status (income, education, etc.) are excluded.

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the type of outcome indicator to use) such an in-depth analysis would require a lot of time and effort even for a small number of studies, and is basically impossible for the 677 studies found in this search.

A possible limitation of the literature search relates to a bias that is closely related to the publication bias, namely the multiple publication bias. The multiple publication bias occurs because studies reporting findings that are significant and “positive” (i.e. finding something) are more likely to be published more than once. Moreover, research questions and databases that produce significant and “positive” findings are also more likely to be analyzed and consequently published. We have tried to exclude earlier versions of an article (e.g. the working paper version) if it was obvious from the title, abstract, and authorship that it was the same study. If there were any differences, however, we included all versions in the review. The in-depth review gives an idea of the relevance of multiple publications biasing the review results. On the one hand, many studies analyzing the same research question employ the same data-sets, which should yield similar results. However, methodological differences between the studies attenuate the multiplication bias as different methods applied on the same datasets yield different results.

Another limitation relates to the large number of studies found in the first step of the search. In view of that, the search strategy appears imprecise, resulting in time and effort required to exclude irrelevant citations. However, the transformation of the economically logical review question into the mathematically logical form requested by sophisticated electronic literature searches is difficult. Thus, fuzziness is inherent in the multidisciplinary of the review. Very likely, a more restrictive search strategy would thus have led to a higher specificity at the expense of the sensitivity.

Finally, a general limitation of the thematic map relates to the study origin. A large part of the published studies are studies relating to the situation in the USA, Canada and Australia. The evidence of those countries may not be applicable to the case of Switzerland and Europe in general, as the environments and culture allegedly differ substantially.<sup>41</sup>

### **6.3.2 The in-depth review**

The evidence base of the studies reviewed in-depth is generally quite low. First of all, most factors or policy measures examined in the studies are very diverse. Therefore, the evidence regarding a specific policy measure is based on one or two studies (e.g. PE requirement law; years of schooling; nutrition labelling act; etc.). This is hardly

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<sup>41</sup> Interesting results applicable to the EU were presented by Kearney and McElhone (1999). With data from a cross-sectional study of adults, they sought to determine the main perceived barriers that people have in trying to eat a healthy diet in the European Union. The main perceived barriers among EU subjects related to time (irregular work hours (24%) and busy lifestyle (17%)) and taste (23%). 15% regarded price as an important barrier to healthy eating. Barriers not considered to be particularly important among the EU sample included the availability of healthy foodstuffs (7%), which is seen as a major barrier in the American research, and the lengthy preparation (8%), which is somewhat contradictory to the statement that time is an important barrier.

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enough foundation for an assessment of the validity of the evidence and the consistency of the results.

For those policy fields where more than one study exists (e.g. cigarette tax or food tax), a comparison of the studies illustrates that they have different study designs, use a variety of analytical methods and are based on data from different sources and collected in various ways. Interestingly, neither the studies assessing the impact of smoking policies nor those estimating the effect of food taxes and subsidies allow for a conclusion because there is no consistent association. For example, cigarette taxes may increase or decrease BMI. Taxing unhealthy foods may also increase or decrease BMI. Moreover, the effect size estimated in the single studies varies substantially. A \$1 increase in cigarette taxes may lower BMI between 0.15 and 0.78 points.

The lack of consistent evidence prohibits any conclusion regarding the applicability of the results. The existing evidence regarding the effect of policy measures on body weight status does therefore not speak to the effects of introducing or altering such legislation; there is no basis for inference of the study results.

Whenever substantial heterogeneity in effects between studies exists we should seek an explanation for this variation. Variations in study characteristics, such as populations, outcome measures, study design, methods of analysis, and quality of the studies, are likely to have some influence on observed effects.

*Populations and outcome measures:* The 14 studies analyzed in this in-depth review use 7 different US population-based datasets, the OECD health statistics database, a Danish cohort study and the TNS WorldPanel household survey to estimate the effect of 23 policy aspects on body weight status. Except for 2 datasets (NHANES and NHES) body weight status was self-reported as opposed to measured in a physical examination. As most data is US-based, most studies are at best representative for USA. The generalizability of these studies to Europe and to Switzerland is restricted. The studies that are based on the OECD health statistics would be potentially more applicable but have the disadvantage that some research questions have to make do with very low numbers of observations as every observation is one country (as opposed to an individual). The results of these studies are thus based on a weak foundation, as the sample sizes of the OECD health statistics are often too small for sound statistical analyses. In general, the lack of data is a major drawback when studying multi-country obesity patterns.

*Study design:* Most of the evidence in the in-depth review comes from cross-sectional comparisons, where the outcome (e.g. body mass) and hypothesised explanatory factors (policy measure) are measured at the same time. This study design is relatively weak, as the simultaneous measurement of cause and effect means allows only conjectures about associations, making conclusions about direction and possible causality of associations impossible. Some research questions reviewed here are suitably analyzed with the help of quasi-natural experiments, such as in the case of the introduction of a PE requirement law, of a school reform, of the introduction of the Nutrition Labeling and Education Act NLEA, and of smoking policies. However, not all policies are implemented nationwide and exogenously. Some states

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or counties self-select their policy measures according to their voting public, and there may be certain on-going processes (health consciousness, for example) in the population that will result in the implementation of a policy measure. The change in body weight status before and after the policy is therefore not necessarily due to the policy. Instead, the policy is a symptom of the on-going change.

*Analytical methods:* The used analytical methods vary greatly between the studies, even between studies researching the same question and using the same database. In general, however, most studies used multivariate analyses (and/or control group), adjusting for other potential personal or environmental correlates of nutrition or physical activity behaviours. Moreover, most studies control for more than one environmental factor/policy measure. Failures to adequately control for these influences can lead to residual confounding, whereby apparent associations with the environmental components being measured are, in fact, associated with other factors that have been inadequately controlled for. Despite the fact that the studies in this in-depth review use multivariate analyses, the model specification will in all likelihood never be sufficiently comprehensive in view of the variety of factors that can influence body weight status. It is very difficult to adequately control for confounding factors in studies of obesogenic environments because (i) the determining factors are so numerous, (ii) datasets are quite restricted, and (iii) many of the factors vary together due to their interconnectedness; including too many of these variables into the statistical model will result in over-specification and we will end up explaining 'everything and nothing'.

*Quality of the studies:* Not all studies are of the same quality, as the quality score indicates. Some studies meet all standards, while others barely fulfil three of them.

As a concluding remark, we find that estimating the impact of macro-level policies on the body weight status on the population level is associated with substantial difficulty and uncertainty. The same databases can produce opposite results, depending on model specifications. The problems of confounding may be serious enough to explain many of the differences reported between the studies discussed, more so than all other study aspects (population, outcome measure, study design). For these reasons, we consider it essentially impossible to estimate the relative importance of each of all the relevant factors.



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## 7 Policy and research recommendations

In this chapter we translate the evidence from the two preceding chapters into practical recommendations for policy makers and future research.

After having identified the hazards of the environment with respect to the energy imbalance and discussed the findings under due consideration of the limitations regarding the validity, consistency and robustness of the findings, we derive recommendations regarding policy activity and research.

**As a starting point**, it seems fundamental to thoroughly appraise the relevance of the findings to the local context in Switzerland by evaluating the exposure of individuals to these hazards (perhaps with a special focus on sensitive groups such as children). Drawing on the results from this review in the PESTEL-framework the Swiss environment needs to be scanned and evaluated regarding potential incentives and disincentives it provides for a positive energy balance. A large part of the research conducted on the environmental determinants of obesity stems from North America. Many domains of the Swiss environment substantially differ from the environment in those countries, such as the sociocultural aspects, policy measures, neighbourhood characteristics and schools.<sup>42</sup> In particular, the neighbourhood segregation in Switzerland will very likely not be as pronounced as in North America. Therefore, the neighbourhood may be of less importance, as perceived by researchers and individuals, in determining obesity in Switzerland than in North America. This first step

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<sup>42</sup> Cummins and Macintyre (2006:102), for example, find robust evidence for the existence of a socio-economic neighbourhood gradient regarding access to and availability of supermarkets and grocery stores selling fresh and healthy foods (i.e. the existence of so called food deserts in deprived areas) for North America but not for Europe. "The social, cultural, economic, and regulatory environment that governs the provision, purchase, and consumption of food is likely to differ markedly between nations and these differences may be expressed at the neighbourhood level within countries. For example, residential segregation along socioeconomic and racial lines may be more pronounced in the USA. In Europe there may be more regulatory controls on new supermarkets in out-of-town sites. Fast food outlets tend to be in the city center in Europe where there are low levels of deprivation while in the US richer people tend to move to the outskirts of cities."

Also, Philipson (2001:5) writes that "Because food is cheaper in the US than in Europe, and most European cities were designed before automobile transportation became common, and because Europe is less suburbanized than the US and pays much higher prices for gasoline than the US, a consequence of much stiffer gasoline taxes, it can be expected that Europeans are less sedentary in their travel. The fundamental cause may simply be higher land prices in Europe, which result in Europeans living much closer to each other and to work and shopping, at distances where walking is more efficient than driving. In addition, the US is the world's leading innovator in passive entertainment, which is highly sedentary. Americans watch television much more than Europeans, in part because American television offers much higher quality, in an economic but not necessarily 'artistic' sense, than European. Indeed, about half the leisure time of the average American is spent watching television – a completely sedentary activity. Other things being equal, the higher the quality of television, the higher is the opportunity cost of recreational exercise and hence the lower the demand for thinness. Television is a particularly peculiar product because the marginal pecuniary cost of consumption is zero (except for pay-TV), and so small increases in perceived quality may lead to significant increases in the amount demanded."

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will serve to identify the need for action regarding the environment aspects in Switzerland in order to halt and reverse the obesity epidemic.

**As a second step**, the possibilities for action and the potential changeability of determinants need to be evaluated. In this context it is important to acknowledge the fact that many of the developments and trends that have led to the environment being obesogenic were in fact part and parcel of progress and increases in social and economic welfare. As such, these developments are not reversible without corresponding losses. Moreover, knowing that a factor contributed to the current obesity epidemic does not provide any indication regarding how effectively a change in this factor is for reversing the obesity epidemic.

A domain of the environment that needs to be looked into particularly critically is that of policy. The question that needs to be answered is in particular: How do existing or planned policies (from all fields) provide incentives and disincentives for energy imbalance and thereby influence obesity? The environment may not only be obesogenic because of rationality failures or market failures but also because of government failures. Similarly, the public authorities as providers of public goods such as playgrounds, sidewalks, bike paths, etc. assume responsibility for the incentives and disincentives conveyed by these public good. In this regard, schools and their possibilities for physical activity and their eating rules are particularly important.

Quite recently, Sacks et al. (2008) offered a systematic policy approach across the food system and full range of the physical activity environment, quite similar to the systematic used in this review. Moreover, they consider policy opportunities for each level of governance (local, state, national, international, and organisational) in each sector of the food system and each sector that influences physical activity environments.

**As a third step**, target-oriented, specific research should be conducted. In view of the urgency of the problem and of the numerous environment factors as potential determinants of obesity it appears important to restrict research to aspects or domains of the environment (a) that are relevant to the case of Switzerland (i.e. the need for action exists), and (b) that can actually be leveraged (i.e. where possibilities for action exist). Thus, in the short-term, research should primarily be solution-oriented and instrumental in halting and reversing the obesity epidemic in Switzerland. In the longer-term, and for preventive reasons, it will be eminent to continue research in a broader sense and to map the whole system of obesity determinants, in collaboration with international researchers. Mapping the system of obesity determinants will help to be prepared for future challenges occurring through further social, technological, economic etc. changes and developments.

With respect to the future research, the following aspects seem to be important:

- More local (or European) research should be conducted for the reasons given above.
- It is essential to learn more about the validity and adequacy of the indicators used. Both the outcome indicators as well as the explanatory variables are not easy to be measured and conceptualized in this context. With respect to the

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outcome indicator, it needs to be decided whether the current obesity epidemic is best measured in terms of BMI or some other measure of obesity such as waist-to-hip ratio or percent body fat, and whether this is to be objectively measured in an examination or to be self-reported in a survey. Also, it needs to be decided whether obesity as a result of the energy balance is relevant or whether physical activity levels or diet choices are important goals independent from body weight status (Jones et al. 2007:34-35). With respect to the explanatory variables, it is necessary to learn more about which indicators represent the relevant aspects of the environment most appropriately. Also, there need to be answers regarding whether different indicators measure different concepts. This is particularly important because of the interconnectedness of the determinants across the domains and across the different levels of the environment (micro-level, meso-level and macro-level).

- Also, it is important to find appropriate ways to account for the complexity of obesity. So far, most studies have used only a small number of explanatory variables simultaneously to explain obesity. Or, when several explanatory variables have been included in the multiple regression model, they have generally been considered singly, i.e. the complex relationship between the various indicators has generally not been accounted for. As a consequence, the effect of single factors on obesity may well have been over- or underestimated so far. Seeing that the steep and sudden rise in obesity prevalence might reasonably be related to the simultaneous presence of a number of obesogenic factors, it seems crucial to test comprehensive models of the determinants of obesity at the environment level. This is necessary to learn more about how the factors actually relate to each other and jointly influence individuals in their decisions.

The problem with including too many explanatory variables at the same time is that the model may end up being over-specified. Technically speaking, there are too many determinants to explain the variance of one single variable (obesity), and one ends up explaining 'nothing by explaining everything'. This problem does not only arise when variables from different environment domains are included in the model specification but when variables within the same domain but from different levels are included simultaneously in so-called multi-level models or ecological models.<sup>43</sup> Multilevel methods currently represent the method of choice to handle data in which individual behaviours are assumed to be influenced both by individual characteristics as well as the higher-level hierarchical groups such as households, neighbourhoods, regions and countries which the individuals are organized into. "Multilevel models allow

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<sup>43</sup> Multilevel models consider base-level units (*individuals*) as organized into hierarchies of successive higher-levels units (*groups*), e.g. households, towns, regions, countries, etc. By simultaneously including both neighbourhood- and individual-level predictors in regression equations with individuals as the units of analysis, multilevel modelling strategies allow examination of neighbourhood or area effects after individual-level confounders have been controlled. (OECD Expert Group on Economics of Prevention 2008:14-15).

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decomposing the overall variance observed in a sample into a within-variance component, reflecting variation among individuals within higher-level groups, and a between-variance component, reflecting variation among higher-level groups.” The issue here thus is that introducing individual-level characteristics into multilevel models (e.g. income, age, lifestyle preferences) in an effort to control for the self-selection of people into higher-level groups (in particular neighbourhoods) there is the risk of explaining away all or most of the true variance if the individual characteristics segregate people into distinctly different types of environments.<sup>44</sup> Researchers are challenged by the dilemma that if they do not control for individual-level attributes that govern the selection process then their estimates are biased due to residual confounding; but when they do introduce such controls, there is nothing left for the neighbourhood-level variables to explain (OECD Expert Group on Economics of Prevention 2008:14-15). See Schwartz (1994) for a discussion on the typical pitfalls when using both micro-level and meso- or macro-level variables simultaneously.

As a recommendation for research, the results of this review suggest that the complex nature of obesity be accounted for in the model specification, through the use of multilevel models, through the use of including multiple explanatory variables from all relevant domains, and through accounting for the interaction of these factors. Clearly, such an integrated approach requires the availability of appropriate data. In view of the restricted availability of datasets which contain a corresponding variety of data, we recommend the cooperation with national agencies collecting data from a variety of fields and with international researchers in order to increase sample sizes and include variability on the macro-level of explanatory variables.

- The fact that most research is based on cross-sectional, observational data renders it impossible to establish a true causal relationship between environment and obesity. Cross-sectional studies allow a statement regarding the existence of a significant association between two variables but because they lack randomization and a control group, it is not evident whether the association is causal or maybe driven by a third variable. For instance, a positive association between TV viewing and body weight status may be because people who watched a lot of TV developed weight problems or because people with weight problems tended to watch a lot of TV, perhaps because physical activ-

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<sup>44</sup> There is the possibility that not meso-level environment factors determine the body weight status of residents but that individuals, based on their own preferences for physical activity or access to healthy food, sort themselves into neighbourhoods that provide desired services. For example, more active individuals may move into areas where the environmental conditions are more supportive for physical activity. Analogically, individuals who are physically active may perceive their environment differently from those who are not physically active. Likewise, supermarkets and health clubs may open outlets in places where demand is high and where they can earn the highest profits. Because of such self-selection, correlations between neighbourhoods and body weight status may arise even though a real causal relationship does not exist. The underlying question to be solved is: when research implies that neighbourhoods are associated with body weight status can one conclude that modifying the neighbourhood will improve body weight status among its current residents?

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ity is more difficult for them or because interacting with peers is less pleasant. Also, the association may be driven by a third variable such as family socio-economic background, which may lead people to both have weight problems and watch more TV.

The best way to assess causality is to conduct an experiment. Clearly, experimental approaches are hardly possible (or ethical) in this context. But exogenous changes that may influence the energy balance change are ongoing every day: areas are (re-)developed, public policies are introduced, fast-food chains open new subsidiaries, people move to different neighbourhoods, worksite or school cafeterias change the food they have on offer. These natural experiments or quasi-experiments should be taken advantage of to investigate the changes in body weight status that occur as their result. Again, since national and local policies differ strongly from one country to another, between-country comparisons could improve our understanding of macro-environmental factors. Unfortunately, the long time lags between a change of behaviour and a noticeable effect on body weight status may limit the practicality of quasi-experiments.

As an alternative, it may be useful to find and compare the body weight status of individuals with similar background characteristics (i.e. micro-level environments) who live in neighbourhoods or states with and without a given attribute (i.e. meso-level or macro-level environment). A related, more sophisticated approach for this comparison is to match individuals from different environment applying propensity scores, which can be used to explicitly match on selection-related factors (such as income, age and education) and therefore ensure comparability.

- In general, in view of the difficulties encountered not only in estimating valid associations but in particular of causality, epidemiological principles of causal inference should be applied for judging whether an association is likely to be causal. Hill (1965) presented aspects of an empirical association that ought to be considered when assessing whether an association is causal.<sup>45</sup> Among them are the strength and consistency of the association, temporality, a 'dose-response gradient', and the theoretical plausibility of the underlying causal path.
- Economics with its rational choice model provides a framework to think about obesity and its determinants. The rational choice model in the obesity issue is often reduced to the interpretation that in economics, there is no such thing as being 'overweight'. Body weight is the result of individual choices that account for the trade-off between long-term health or well-being and short-term bene-

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<sup>45</sup> However, Hill's nine aspects are not criteria for inferring causality of associations in such a manner as that all the conditions are necessary to be fulfilled. None of the nine aspects can bring indisputable evidence for or against the cause-and-effect hypothesis and only one of them (temporality, as cause must precede effect) can be required as a sine qua non.

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fits of food intake and sedentary leisure time.<sup>46</sup> Rational choice theory suggests that people freely choose their body weight, and since it is a free and rational decision and individuals are sovereign, there is no need for the government or anyone to intervene. However, there are situations in which this free, rational choice does not necessarily lead to an optimal outcome. Among these situations are the following:

- Individuals lack information and thus base their decisions on incomplete information. This problem may be leveraged with schooling, health education and information dissemination. With incomplete information there is the risk that individuals cannot distinguish between knowledge and other pieces of information spread for example via advertising.
- Individuals lack rationality and therefore cannot correctly integrate all relevant (in particular the future) consequences in their decision-making, e.g. due to myopic preferences, time-inconsistent preferences, self-control problems or addictions. With adults there is generally an assumption of consumer sovereignty in economics. In contrast, children are generally accepted to be unable to weigh the future consequences of their actions. Therefore, children are generally supervised by adults and protected by the government.
- Individuals' lifestyle choices cause externalities and impose costs on 'innocent' others. In relation to obesity, externalities may arise in the form of health expenditures and social security payments that are borne by the collective. Externalities in the form of health effects may arise through the social multiplier effect. The social multiplier effect may cause obesity to spread particularly fast among families, peer groups and social networks. If individuals are not the only ones who bear the consequences of their decisions, the government ought to protect the 'innocent' others from being affected.

Under these situations, people generally tend to make wrong decisions when they are left at their own. Interventions through governments, for example through health education or regulations to assist self-control of individuals, might improve the outcome. All three aspects are applicable to the case of obesity, but it is subject to discussion whether they are in fact relevant.

There is an entire field called behavioural economics that studies these departures from rationality. Further obesity research should also aim at quantifying the prevalence of these situations in the population and to assess its role in eating and physical activity behaviours in order to corroborate government activity in this context.

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<sup>46</sup> Graham and Felton (2005) find evidence for this theory. They report that populations of different ethnicity or socioeconomic status associate substantially different losses of well-being with weight gain (as a result of differing body weight norms etc.). These systematic differences are found to be mirrored in systematic differences in body weight between these groups. If weight gain is associated with higher costs people tend to gain weight less often.

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Also, if the possibility of irrational consumer behaviour exists, it might be worthwhile to investigate in what ways businesses try to respond to this irrationality. For example, would increased marketing and promotion of calorie-dense foods and increasing portion sizes be an optimal producer response when consumers face self-control problems? On the other hand, there may be interesting ways for businesses to help people with their problems. Other fields have found ways to deal with self-control problems, for example retirement savings plans, or health retreats that only serve specific health foods. In this context, another need to better understand ways to make businesses interested in providing similar self-control-techniques, such as selling smaller packages to restrict consumption, being transparent about the nutrition content of foods, etc..

**In a final step**, all stakeholders should begin modifying environments in ways that would make healthy choices easy choices.

Obesity, as a result of energy intake and energy expenditure, will always be a consequence of individual choices. However, the significance of structural conditions in determining these individual choices must not be undervalued. Economics provides a framework that explicitly accounts for external incentives as strong determinants of individual behaviour. Economics with its rational choice model enables framing the obesity issue not as an individual problem but as a consequence of the incentive system. This, in turn is important for deciding how obesity is to be addressed: “Who or what is perceived as responsible for the genesis of obesity is a prime determinant of how obese individuals are received by society and what actions are considered appropriate for both treatment and prevention“(Schwartz and Brownell 2007:79).

This review has shown that the obesity problem is not necessarily a problem of individual failure but that it is to a large extent systemic. As long as the environment makes healthy choices difficult or more costly, it will be difficult to expect individuals to change their behaviour.<sup>47</sup> Targeting individuals through educational programs to change their behaviour may simply not be enough if, simultaneously, they are expected to control their weight in a land of milk and honey. The obesity problem may not be so much a matter of ignorance but of incentives. If incentives as opposed to information are the issue then increased public education on how to stay in shape and lose weight may have limited effects. The challenge is to create supportive environments for making the healthy choices which are promoted by the education messages. Or, as Friedman (2003) put it: to start “a war on obesity, not the obese”.

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<sup>47</sup> „Historically, obesity has been blamed on the individual. It is still the case today that a failure of ‘personal responsibility’ is evoked as obesity’s cause, and imploring individuals to change is often the implicit and explicit solution (Schwartz and Brownell 2007:79). Analyzing newspapers and television news, Kim and Willis (2007) explored how the media have framed the question of who is responsible for causing and fixing obesity. They found that mentions of personal causes significantly outnumbered societal attributions of responsibility. The media also made more references to individuals than to society in discussing solutions.

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## Appendix I: Inclusion/exclusion criteria

**Table 10** Inclusion criteria for the systematic review

	Inclusion criteria:
<b>Exposure</b>	<ul style="list-style-type: none"> <li>• ‘Anything outside the individual’, in particular the political/legal, economic, sociocultural, technological and natural/physical environment</li> </ul>
<b>Population</b>	<ul style="list-style-type: none"> <li>• Individuals with residence in industrialized, western countries: USA, Canada, Europe, Australia, New Zealand; regardless of their migration background.</li> <li>• General population or sub-populations with respect to cultural, ethnic, socioeconomic, socio-demographic, geographic (and similar factors) background</li> </ul>
<b>Outcome measures</b>	<ul style="list-style-type: none"> <li>• Any measure of overweight</li> <li>• Any measure of obesity</li> </ul>
<b>Study design</b>	<ul style="list-style-type: none"> <li>• Empirical quantitative studies:               <ul style="list-style-type: none"> <li>- Original work: experimental studies (randomised controlled trials), observational studies (cohort studies, case-control studies, cross-sectional studies)</li> </ul> </li> </ul>

**Table 11** Exclusion criteria for the systematic review

	Exclusion criteria:
<b>Population</b>	<ul style="list-style-type: none"> <li>• Individuals with residence in Africa, Asia, Greenland, Latin America and the South Pacific</li> <li>• Individuals of age 80 years and older</li> <li>• Newborn (defined as age birth to 1 month) and infants (defined as age 1 to 23 months)</li> <li>• Sub-populations consisting of morbid patients, high-risk patients and patients involved in clinical treatment.</li> <li>• Animal studies</li> </ul>
<b>Outcome measures</b>	<ul style="list-style-type: none"> <li>• Studies reporting on weight-related indicators such as blood pressure, glycaemic index, etc. only</li> <li>• Studies reporting on physical activity and eating behaviour only</li> </ul>
<b>Study design</b>	<ul style="list-style-type: none"> <li>• Systematic reviews on original work as above</li> </ul>

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	<ul style="list-style-type: none"><li>• Theoretical models only</li><li>• Studies with qualitative analysis only</li><li>• Studies that are descriptive in nature only</li></ul>
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## Appendix II: Search strategy electronic medical database

In the following we explain the systematic search strategy for the electronic medical database Medline. This Medline-specific search strategy was then translated to be used in the other medical databases EMBASE, Cochrane Library, PsycINFO, Psyn-dex Plus, and is thus conceptually identical.

The logical procedure when conducting a systematic search strategy is to first draw a pool of references that satisfy certain criteria out of the immense pool of references in the electronic database (rectangle in Figure 9 below). The larger this rectangle the more sensitive is the search (i.e. little risk of missing relevant articles) and the less specific are the results (i.e. large risk of capturing non-relevant articles). In a second step, one aims at reducing this first pool of references to get a more specific search (illustrated by circular pool in Figure 9 below). Therefore, the references in the rectangle pool that are not relevant will be “dismissed”.

In the case of the current review this was done as follows:

In the first step, the search strategy for the electronic medical databases considered references relevant when they employed either of the terms “obesity” or “overweight” (as the facet *Outcome*) as MESH terms or as free text words in title and abstract in combination with either one of the following MESH terms mirroring environment characteristics (as the facet *Exposure*):

- “Taxes”
- “Residence characteristics”
- “Transportation”
- “Technology”
- “Food industry”
- “Commerce”
- “Architecture as topic”
- “Schools”
- “Social planning”
- “Socioeconomic factors”

In the second step, this first pool of references was then screened for the following characteristics in order to exclude references that would meet the following Mesh terms as exclusion criteria:

- Publication types: “Comments”, “Letter”, “Case Reports”, “Editorial”, “Interview”, “News”, or “Patient Education Handout”
- Publication date: References with a publication date before 1980\*
- Publication language: Languages other than English, French, German, Italian, Spanish\*

- 
- Study subjects (as the facet *Population*):
    - “All Infant: birth-23 months” (comprising “Infant: 1-23 months” and “New-born: birth-1 month”), people aged 80 years and older \*
    - Geographic region: “Caribbean Region”, “Central America”, “Latin America”, “South America”, “Atlantic Islands”, “Pacific Islands”, “Asia”, “Africa”, or “Indian Ocean Islands”
    - Animal studies were excluded\*
  - Medical treatments and conditions: “Patient Care Management”, “Dentistry”, “Anesthesia and Analgesia”, “Surgical Procedures, Operative\*”, “Bariatrics”\*\*, “Drug Therapy”\*\*, “Mental Disorders”, “Psychological Phenomena and Processes”, “Genetic Phenomena”, “Genetic Processes”, “Genetic Structures”, “Digestive System Diseases”, “Nervous System Diseases”, “Skin and Connective Tissue Diseases”, “Respiratory Tract Diseases”, “Male Urogenital Diseases”, “Female Urogenital Diseases and Pregnancy Complications”, “Animal Structures”, “Embryonic Structures”, “Hemic and Immune Systems”, “Integumentary System”, “Musculoskeletal System”, “Nervous System”, “Respiratory System”, “Stomatognathic System”, “Urogenital System”, “Diabetes Mellitus”\*\*, “Insulin”\*\*, “Islets of Langerhans”, “Langerhans Cells”, “Serum”, “Atherosclerosis”, “Postpartum Period”\*\*, “Pregnancy”\*\*, “Gastroplasty”, “Neoplasms”\*\*, “Disabled Persons”\*\*, or “weight-loss program”\*\*\*

\* *These criteria could not be conducted in all medical databases and was conducted by hand instead.*

\*\* *These Mesh terms were also searched as free text (in identical or similar wording) in title and abstract of the references*

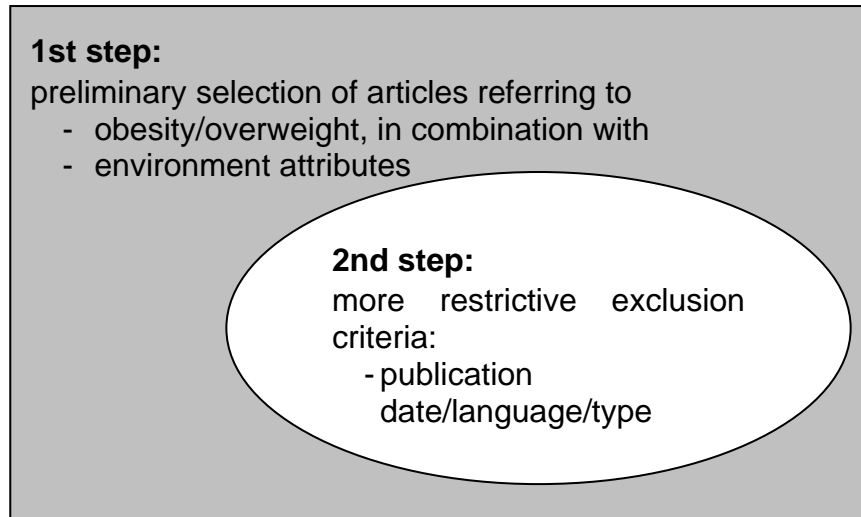
\*\*\* *This term was only searched as free text in title and abstract of the references*

We have not defined any criteria regarding the facet *Study Design*. As discussed above, the reason for this is that for this literature review the evidence will most likely stem from observational studies, and applying in- and exclusion criteria to the facet *Study Design* for observational studies is critical as is stated in the CRD guideline: “Trying to identify observational studies with precision can be very difficult. This is because there are many types of study design and the nomenclature is not standardised, with the result that imaginative searching with lots of synonyms is required. Moreover, in some databases subject indexing by study design may not be available or reliable.” Thus, by incorporating *Study Design* facets into the electronic database search we would run the risk of dismissing potentially relevant studies. Thus, we followed the safe option given by the CRD guidelines by not incorporating explicit in- and exclusion criteria of the facet *Study Design*: “However, depending on the complexity of the question and the range of study designs of interest, it may sometimes be more effective, in terms of the length of the strategy and a wish to maximise sen-

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sitivity, to omit a study design facet from the search strategy.” (NHS Centre for Review and Dissemination 2001:5 (phase 3))

**Figure 9** Graphic illustration of search strategy



The strategy followed for this review was to make a very sensitive search in the first step. This naturally yielded a large number of references in the “rectangle pool”. An alternative would have been to apply further inclusion criteria in the first step that would need to be fulfilled in combination with the inclusion criteria overweight/obesity and environment attributes. The rationale for not applying further inclusion criteria was that many relevant articles for this review have a social science or economic background, and there is the risk that in the medical databases these articles are not labelled and coded as completely and thoroughly as articles from medical science. Thus, instead of applying strict inclusion criteria in the first step in order to create a relatively manageable pool of references but at the risk of losing many relevant (but scarcely labelled) articles, we decided to conduct a relatively ample preliminary selection of articles. In the second step of the article selection we further dealt with the risk of incomplete labelling of some articles by applying strict exclusion criteria instead of further inclusion criteria. Thus, articles were only dismissed if they explicitly exhibited labels regarding specific publication types, study subject characteristics, or medical conditions and treatments. Again, this minimizes the risk of excluding articles that are in fact relevant for this literature review. However, the drawback of this strategy is the fact that it still leaves a large number of references in the “circular pool”, many of which are not relevant (but incompletely labelled).

The articles in this large pool were then inspected individually (by the information available from the title and abstract, and if necessary, from the entire article) in order to separate the pertinent articles.

The fact that we excluded a large number of non-relevant articles from this second-step pool that were not excluded on the basis of labels but clearly should have been according to their content is an indication of the incomplete labelling of articles, which lead to and justifies the fairly laborious strategy conducted for this literature review.

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Further and more detailed information regarding the search strategies in the medical databases can be obtained by the authors of this review.

## Appendix III: Quality assessment checklists

**Table 12** Checklist quality items

No.*	Items	Comment/criteria	No/Yes/Unclear
1 ext	<b>Population characteristics</b> described in sufficient detail (number of subjects, demographic, socio-economic characteristics)?	Number of subjects and their distribution by at least 3 characteristics (e.g. population, gender, age, education, ethnicity, morbidity, etc.) are described.	
2 ext	<b>Recruitment of population / data sources</b> for each variable of interest described in sufficient detail?	Qualitative description of recruitment /data sources is sufficient.	
3 int	<b>Outcome measurement</b> described in sufficient detail?	Unambiguous definition of outcome indicator for overweight/obesity (such as weight and height, waist circumference, percentage body fat, etc.) and measurement method (i.e. whether outcome indicator was measured or self-reported). If applicable, description of which groupings were chosen and why.	
4 int	<b>Measurement of determinants described in sufficient detail?</b>	Description of environment indicator and measurement method (i.e. whether environment indicator was measured or self-reported, and whether it is based on perceptions or objective determination). If applicable, description of which groupings were chosen and why.	
5 int	<b>Completeness of follow-up</b> in cohort studies	Completeness fulfilled if ? 80%. If completeness not fulfilled, explain how loss to follow-up was addressed.	
6/7/8 int	<b>Analysis:</b> adequate techniques used?	Explained how missing data were addressed.	
		Reporting of measures of uncertainty for main results (e.g. confidence interval).	
		Confounding is accounted for (restriction; stratification (subgroup analysis, interactions); multivariate models; randomization).	
9 ext	<b>Sensitivity analysis</b> performed to address uncertainty?	Description of sensitivity analysis and variability of results.	

\* int: items addressing internal validity; ext: items addressing external validity

Source: adapted from items 8-12 of the STROBE Statement



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## Appendix IV: Reference lists

### Political and legal environment

Topic	n	References
Civil law origin	1	(Cutler et al. 2003)
Governance	1	(Rabin et al. 2007)

Cutler, D., E. Glaeser, et al. (2003). "Why have Americans become more obese?" Journal of Economic Perspectives **17**(3): 93-118

Rabin, B. A., T. K. Boehmer, et al. (2007). "Cross-national comparison of environmental and policy correlates of obesity in Europe." European Journal of Public Health **17**(1): 53-61

## Economic environment

### Macro-level economic factors

Topic	n	References
economic cycle / growth (GDP)	11	(Cutler et al. 2003) (Stillman and Thomas 2004) (Loureiro and Nayga 2005) (Ruhm 2005) (Böckerman et al. 2007) (Bua et al. 2007) (Rabin et al. 2007) (Ulijaszek and Koziel 2007) (Bleich et al. 2008) (Costa i Font et al. 2008) (Regidor et al. 2008)
income per capita	3	(Vandegrift and Yoked 2004) (Kim et al. 2006) (Lin et al. 2007)
(un)employment rate	4	(Vandegrift and Yoked 2004) (Loureiro and Nayga 2005) (Mandal and Chern 2007) (Rabin et al. 2007)
income inequality	10	(Kahn et al. 1998) (Diez-Roux et al. 2000) (Chang and Christakis 2005) (Pickett et al. 2005) (Kim et al. 2006) (Mobley et al. 2006) (Mandal and Chern 2007) (Pickett and Wilkinson 2007) (Regidor et al. 2008) (Singh et al. 2008)
% with given educational attainment (inequality)	2	(Rabin et al. 2007) (Regidor et al. 2008)
food stamp participation rate	1	(Mandal and Chern 2007)
unregulated market forces	2	(Cutler et al. 2003) (Bleich et al. 2008)
transition to market economy	10	(Heinemann et al. 1996) (Bobak et al. 1997) (Dennis et al. 2000) (Jahns et al. 2003) (Koziel et al. 2004) (Chrzanowska et al. 2007) (Denisova et al. 2007) (Huffman and Rizov 2007) (Huffman and Rizov 2007) (Kromeyer-Hauschild and Zellner 2007)

<b>Topic</b>	<b>n</b>	<b>References</b>
food prices	13	(Lakdawalla and Philipson 2002) (Cutler et al. 2003) (Chou et al. 2004) (Loureiro and Nayga 2005) (Sturm and Datar 2005) (Courtemanche 2007) (Gelbach et al. 2007) (Powell et al. 2007) (Powell and Bao 2007) (Bleich et al. 2008) (Etilé 2008) (Miljkovic et al. 2008) (Schroeter et al. 2008)
gasoline prices	3	(Courtemanche 2007) (Gelbach et al. 2007) (Rabin et al. 2007)

Bleich, S., D. M. Cutler, et al. (2008). "Why is the developed world obese?" NBER Working Paper Series No. 12954

Bobak, M., Z. Skodova, et al. (1997). "Political changes and trends in cardiovascular risk factors in the Czech Republic, 1985-92." Journal of Epidemiology & Community Health **51**(3): 272-7

Böckerman, P., E. Johansson, et al. (2007). "The physical strenuousness of work is slightly associated with an upward trend in the Body Mass Index." Working Paper Series No. 523

Bua, J., L. W. Olsen, et al. (2007). "Secular trends in childhood obesity in Denmark during 50 years in relation to economic growth." Obesity Research **15**(4): 977-985

Chang, V. W. and N. A. Christakis (2005). "Income inequality and weight status in US metropolitan areas." Social Science & Medicine **61**(1): 83-96

Chou, S. Y., M. Grossman, et al. (2004). "An economic analysis of adult obesity: Results from the Behavioral Risk Factor Surveillance System." Journal of Health Economics **23**(3): 565-87

Chrzanowska, M., S. Koziel, et al. (2007). "Changes in BMI and the prevalence of overweight and obesity in children and adolescents in Cracow, Poland, 1971-2000." Economics & Human Biology **5**(3): 370-378

Costa i Font, J., D. Fabbri, et al. (2008). "Decomposing body mass index gaps between Mediterranean countries: A counterfactual quantile regression analysis." Working Paper Series No. 2008-11

Courtemanche, C. (2007). "A silver lining? The connection between gasoline prices and obesity." Working Paper

Cutler, D., E. Glaeser, et al. (2003). "Why have Americans become more obese?" Journal of Economic Perspectives **17**(3): 93-118

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- Huffman, S. K. and M. Rizov (2007). "Determinants of obesity in transition economies: The case of Russia." Economics & Human Biology **5**(3): 379-391
- Huffman, S. K. and M. Rizov (2007). "The rise of obesity in transition economies: Theory and evidence from the Russian Longitudinal Monitoring Survey." LICOS Discussion Papers Series **No. 18507**
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- Kahn, H. S., L. M. Tatham, et al. (1998). "Are geographic regions with high income inequality associated with risk of abdominal weight gain?" Social Science & Medicine **47**(1): 1-6
- Kim, D., S. V. Subramanian, et al. (2006). "US state- and county-level social capital in relation to obesity and physical inactivity: A multilevel, multivariable analysis." Social Science & Medicine **63**(4): 1045-59
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- Miljkovic, D., W. Nganje, et al. (2008). "Economic factors affecting the increase in obesity in the United States: Differential response to price." Food Policy **33**(1): 48-60
- Mobley, L. R., E. D. Root, et al. (2006). "Environment, obesity, and cardiovascular disease risk in low-income women." American Journal of Preventive Medicine **30**(4): 327-332
- Pickett, K. E., S. Kelly, et al. (2005). "Wider income gaps, wider waistbands? An ecological study of obesity and income inequality." Journal of Epidemiology & Community Health **59**(8): 670-674
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- Schroeter, C., J. Lusk, et al. (2008). "Determining the impact of food price and income changes on body weight." Journal of Health Economics **27**(1): 45-68
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## Meso-level economic factors

Topic	n	References
Area socio-economic status	40	(Lissau-Lund-Sorensen and Sorensen 1992) (Sherry et al. 1992) (White et al. 1995) (Ellaway et al. 1997) (Reijneveld 1998) (Smith et al. 1998) (Sundquist et al. 1999) (Kinra et al. 2000) (Reidpath et al. 2002) (van Lenthe and Mackenbach 2002) (Chaix and Chauvin 2003) (Kling et al. 2004) (Robert and Reither 2004) (Dummer et al. 2005) (King et al. 2001) (Lamerz et al. 2005) (Oliver and Hayes 2005) (Veugelers and Fitzgerald 2005) (Glass et al. 2006) (Inagami et al. 2006) (Janssen et al. 2006) (Lee et al. 2006) (Mobley et al. 2006) (Monden et al. 2006) (Nelson et al. 2006) (Zhang et al. 2006) (Chen and Paterson 2006 ) (Brown and Siahpush 2007) (Drewnowski et al. 2007) (Liu et al. 2007) (Lopez 2007) (Phuong Do et al. 2007) (Proper et al. 2007) (Vergier et al. 2007) (Vieweg et al. 2007) (Wang et al. 2007) (Grafova et al. 2008) (Oliver and Hayes 2008) (Regidor et al. 2008) (Singh et al. 2008)

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Chaix, B. and P. Chauvin (2003). "Tobacco and alcohol consumption, sedentary lifestyle and overweightness in France: A multilevel analysis of individual and area-level determinants." European Journal of Epidemiology **18**(6): 531-8

Chen, E. and L. Paterson (2006 ). "Neighborhood, family, and subjective socioeconomic status: How do they relate to adolescent health?" Health Psychology **25**(6): 704-14

Drewnowski, A., C. D. Rehm, et al. (2007). "Disparities in obesity rates: Analysis by ZIP code area." Social Science & Medicine **65**(12): 2458-63

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- Glass, T. A., M. D. Rasmussen, et al. (2006). "Neighborhoods and obesity in older adults: The Baltimore Memory Study." American Journal of Preventive Medicine **31**(6): 455-63
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- Janssen, I., W. F. Boyce, et al. (2006). "Influence of individual- and area-level measures of socioeconomic status on obesity, unhealthy eating, and physical inactivity in Canadian adolescents." American Journal of Clinical Nutrition **83**(1): 139-45
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- Kinra, S., R. P. Nelder, et al. (2000). "Deprivation and childhood obesity: A cross sectional study of 20,973 children in Plymouth, United Kingdom." Journal of Epidemiology & Community Health **54**(6): 456-60
- Kling, J., J. B. Liebman, et al. (2004). "Moving to opportunity and tranquility: Neighborhood effects on adult economic self-sufficiency and health from a randomized housing voucher experiment." Working Paper Series **No. 860**
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- Zhang, X., K. K. Christoffel, et al. (2006). "Identification of contrastive and comparable school neighborhoods for childhood obesity and physical activity research." International Journal of Health Geographics **5**: 14



## Micro-level economic factors: Time constraints and time preference

Topic	n	References
time constraints	1	(Joshu et al. 2008)
employment status and overtime work as a proxy for time constraints	39	(Kok et al. 1982) (Shah et al. 1989) (Shewry et al. 1992) (Rosmond et al. 1996) (Rosmond and Bjorntorp 1999) (Sarlo-Lahteenkorva and Lahelma 1999) (Binkley et al. 2000) (Lahti-Koski et al. 2000) (Shankar et al. 2000) (Martinez-Ros et al. 2001) (Vescio et al. 2001) (Ball et al. 2002) (Ball et al. 2003) (Cutler et al. 2003) (La Rosa et al. 2003) (Patt et al. 2004) (Robert and Reither 2004) (Vandegrift and Yoked 2004) (Hollingsworth and Hauck 2005) (Loureiro and Nayga 2005) (Sanz De Galdeano 2005) (Ali and Lindstrom 2006) (Heineck 2006) (Kilicarslan et al. 2006) (McMunn et al. 2006) (Nielsen et al. 2006) (Sarlo-Lahteenkorva et al. 2006) (Sarlo-Lahteenkorva et al. 2006) (Schneider and Schneider 2006) (Cantarero and Pascual 2007) (Keuffel 2007) (Mandal and Chern 2007) (Powell et al. 2007) (Proper et al. 2007) (Rabin et al. 2007) (Costa i Font et al. 2008) (Courtemanche 2008) (Garcia Villar and Quintana-Domeque 2008) (Goode et al. 2008)
rate of time discounting	3	(Komlos et al. 2003) (Smith et al. 2005) (Borghans and Golsteyn 2006)

Ali, S. M. and M. Lindstrom (2006). "Socioeconomic, psychosocial, behavioural, and psychological determinants of BMI among young women: Differing patterns for underweight and overweight/obesity." *European Journal of Public Health* **16**(3): 325-31

Ball, K., G. Mishra, et al. (2002). "Which aspects of socioeconomic status are related to obesity among men and women?" *International Journal of Obesity and Related Metabolic Disorders* **26**(4): 559-65

Ball, K., G. Mishra, et al. (2003). "Social factors and obesity: An investigation of the role of health behaviours." *International Journal of Obesity* **27**(3): 394-403

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- Cutler, D., E. Glaeser, et al. (2003). "Why have Americans become more obese?" Journal of Economic Perspectives **17**(3): 93-118
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Topic	n	References
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## Sociocultural environment

### Macro-level sociocultural factors

Topic	n	References
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maternal employment	23	(Frank and Langhof 1982) (Duran-Tauleria et al. 1995) (Guillaume et al. 1997) (Melnik et al. 1998) (Anderson et al. 2003) (Anderson et al. 2003) (Stettler et al. 2004) (Classen and Hokayem 2005) (Ruhm 2005) (Fertig et al. 2006) (García et al. 2006) (Phipps et al. 2006) (Cawley and Liu 2007) (Courtemanche 2007) (Hesketh et al. 2007) (Mahler 2007) (Powell et al. 2007) (Verger et al. 2007) (Von Hinke Kessler Scholder 2007) (Wronka and Pawlinska-Chmara 2007) (Zhu 2007) (Hawkins et al. 2008) (Yee Fei 2008)
...parental non-standard work schedules	3	(Chowhan and Stewart 2007) (Hawkins et al. 2008) (Miller and Han 2008)
...parent being home when child gets home	1	(Arluk et al. 2003)
...food eaten away from home / meal source	14	(Shah et al. 1989) (Binkley et al. 2000) (Burns et al. 2002) (Lin et al. 2004) (Thompson et al. 2004) (Simmons et al. 2005) (Veugelers and Fitzgerald 2005) (Fertig et al. 2006) (Viner and Cole 2006) (Boutelle et al. 2007) (Courtemanche 2007) (Duffey et al. 2007) (Mandal and Chern 2007) (Michaud et al. 2007)

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## Meso-level sociocultural factors

Topic	n	References
neighborhood social cohesion, support, and network	11	(Kling et al. 2004) (Ali and Lindstrom 2006) (Cohen et al. 2006) (Kim et al. 2006) (Novak et al. 2006) (Poortinga 2006) (Stafford et al. 2007) (Wilson et al. 2007) (Grafova et al. 2008) (Mujahid et al. 2008) (Singh et al. 2008)
civic participation, club membership	6	(Veenstra et al. 2005) (Ali and Lindstrom 2006) (Kim et al. 2006) (Novak et al. 2006) (Poortinga 2006) (Cantarero and Pascual 2007)

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## Micro-level sociocultural factors: Family rules

Topic	n	References
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Snacking	3	(Stettler et al. 2004) (Vignerova et al. 2004) (Dubois et al. 2008)
Meals while watching TV	3	(Stettler et al. 2004) (Veugelers and Fitzgerald 2005) (Dubois et al. 2008)
Frequency of family meals	3	(Taveras et al. 2005) (Veugelers and Fitzgerald 2005) (Gable et al. 2007)
Parent in room while eating dinner	1	(Trogon et al. 2008)
Parental control over intake	3	(Robinson et al. 2001) (Crossman et al. 2006) (Gray et al. 2007)
Parent engaging in PA with child	3	(Sallis et al. 1988) (Arluk et al. 2003) (Sturm and Datar 2005)

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## Micro-level sociocultural factors: Other people's body weight

Topic	n	References
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<b>Topic</b>	<b>n</b>	<b>References</b>
Body weight of partner	2	(Rona and Morris 1982) (Jeffery and Rick 2002)
Body weight of peers	6	(Christakis and Fowler 2007) (Climaco et al. 2007) (Grafova and Thakur 2007) (Halliday and Kwak 2007) (Cohen-Cole and Fletcher 2008) (Trogon et al. 2008)
Body weight image	3	(Burke and Heiland 2007) (Climaco et al. 2007) (Hammond and Epstein 2007)

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## Technological environment

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Agricultural output and productivity	3	(Loureiro and Nayga 2005) (Rabin et al. 2007) (Ulijaszek and Koziel 2007)
Processed food	5	(Macinnis and Rausser 2005) (Rashad 2007) (Richards et al. 2007) (Vartanian et al. 2007) (Etilé 2008)
Meal size	1	(Young and Nestle 2002)
Food advertising	5	(Lewis and Hill 1998) (Chou et al. 2005) (Lobstein and Dibb 2005) (Carter 2006) (Salinsky 2006)
availability of sedentary leisure options through wide availability of TVs	5	(Dennison et al. 2002) (Adachi-Mejia et al. 2007) (Delmas et al. 2007) (van Zutphen et al. 2007) (Wang et al. 2007)
... or IT revolution in general	2	(Krassas et al. 2001) (Komlos et al. 2008)
... reviews of TV viewing / screen time	5	(Caroli et al. 2004) (Marshall et al. 2004) (Carter 2006) (Foster et al. 2006) (Rey-Lopez et al. 2008)
Physical strenuousness of the job	13	(Haglund 1987) (Shah et al. 1989) (Martinez et al. 1999) (King et al. 2001) (Lakdawalla and Philipson 2002) (Vandegrift and Yoked 2004) (Mummery et al. 2005) (Nielsen et al. 2006) (Böckerman et al. 2007) (Graff-Iversen et al. 2007) (Kaleta et al. 2007) (Proper et al. 2007) (Bleich et al. 2008)

<b>Topic</b>	<b>n</b>	<b>References</b>
Transport-related physical activity (cars, elevators)	18	(Giles-Corti et al. 2003) (Frank et al. 2004) (Gordon-Larsen et al. 2005) (Heelan et al. 2005) (Hinde and Dixon 2005) (Loureiro and Nayga 2005) (Ball and Crawford 2006) (Fertig et al. 2006) (Lopez-Zetina et al. 2006) (Rosenberg et al. 2006) (Wen et al. 2006) (Lin et al. 2007) (Pendola and Gen 2007) (Rabin et al. 2007) (Komlos et al. 2008) (Lindstrom 2008) (Ming Wen and Rissel 2008)
Stress-level	7	(Rasky et al. 1996) (Rosmond et al. 1996) (Rosmond and Bjorntorp 1999) (Hannerz et al. 2004) (Robert and Reither 2004) (Veenstra et al. 2005) (Brunner et al. 2007)

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## Natural/physical environment

### Macro-level environmental factors

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Degree of urbanization	5	(Ezzati et al. 2005) (Jackson et al. 2005) (Loureiro and Nayga 2005) (Rabin et al. 2007) (Bleich et al. 2008)
Population density	9	(Komlos and Lauderdale 2004) (Maddock 2004) (Vandegrift and Yoked 2004) (Kim et al. 2006) (Zhang et al. 2006) (Courtemanche 2007) (Lopez 2007) (O'Malley et al. 2007) (Pendola and Gen 2007)



Topic	n	References
Rural vs urban residence	44	(Kok et al. 1982) (Dietz and Gortmaker 1984) (Haglund 1987) (Reeder et al. 1997) (McMurray et al. 1999) (Rasmussen et al. 1999) (Binkley et al. 2000) (van Lenthe et al. 2000) (Cota et al. 2001) (Martinez-Ros et al. 2001) (Moreno et al. 2001) (Strauss and Pollack 2001) (Wang 2001) (Ramsey and Glenn 2002) (Schoenborn et al. 2002) (Klein-Platat et al. 2003) (Ekblom et al. 2004) (Huot et al. 2004) (Patterson et al. 2004) (Plotnikoff et al. 2004) (Vignerova et al. 2004) (Booth et al. 2005) (Classen and Hokayem 2005) (Dollman and Pilgrim 2005) (Lamerz et al. 2005) (Manios et al. 2005) (Padez et al. 2005) (Savva et al. 2005) (Veugelers and Fitzgerald 2005) (Borders et al. 2006) (Fertig et al. 2006) (Lewis et al. 2006) (Poortinga 2006) (Brown and Siahpush 2007) (Lutfiyya et al. 2007) (Mahler 2007) (Mandal and Chern 2007) (Powell et al. 2007) (Reas et al. 2007) (Verger et al. 2007) (Wronka and Pawlinska-Chmara 2007) (Etilé 2008) (Oliver and Hayes 2008) (Sahn 2008)

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## Meso-level environmental factors: Neighbourhood

Topic	n	References
availability / proximity / density of restaurants	10	(Chou et al. 2004) (Rashad et al. 2005) (Simmons et al. 2005) (Sturm and Datar 2005) (Anderson and Matsa 2007) (Powell et al. 2007) (Powell et al. 2007) (Powell and Bao 2007) (Stafford et al. 2007) (Mehta and Chang 2008)
availability / proximity / density of fast food outlets	16	(Reidpath et al. 2002) (Burdette and Whitaker 2004) (Chou et al. 2004) (Maddock 2004) (Simmons et al. 2005) (Sturm and Datar 2005) (Jeffery et al. 2006) (Cash et al. 2007) (Liu et al. 2007) (Lopez 2007) (Powell et al. 2007) (Powell et al. 2007) (Powell and Bao 2007) (Stafford et al. 2007) (Dunn 2008) (Li et al. 2008)
availability / proximity / density of grocery stores	10	(Sturm and Datar 2005) (Inagami et al. 2006) (Morland et al. 2006) (Liu et al. 2007) (Lopez 2007) (Powell et al. 2007) (Powell et al. 2007) (Powell and Bao 2007) (Wang et al. 2007) (Mujahid et al. 2008)

neighbourhood physical activity environment	51	(Liu et al. 2002) (Catlin et al. 2003) (Ewing et al. 2003) (Giles-Corti et al. 2003) (Saelens et al. 2003) (Burdette and Whitaker 2004) (Frank et al. 2004) (Kelly-Schwartz et al. 2004) (Kling et al. 2004) (Lopez 2004) (Vandegrift and Yoked 2004) (Burdette and Whitaker 2005) (Ellaway et al. 2005) (Loureiro and Nayga 2005) (Rutt and Coleman 2005) (Timperio et al. 2005) (Boehmer et al. 2006) (Doyle et al. 2006) (Ewing et al. 2006) (Frank et al. 2006) (Glass et al. 2006) (Gordon-Larsen et al. 2006) (Kim et al. 2006) (Lumeng et al. 2006) (Mobley et al. 2006) (Nelson et al. 2006) (Poortinga 2006) (Zhang et al. 2006) (Berke et al. 2007) (Boehmer et al. 2007) (Eid et al. 2007) (Frank et al. 2007) (Gable et al. 2007) (Kligerman et al. 2007) (Liu et al. 2007) (Lopez 2007) (Merchant et al. 2007) (Moffat and Galloway 2007) (Plantinga and Bernell 2007) (Plantinga and Bernell 2007) (Rundle et al. 2007) (Stafford et al. 2007) (Tilt et al. 2007) (Wilson et al. 2007) (Courtemanche 2008) (Grafova et al. 2008) (Joshu et al. 2008) (Li et al. 2008) (Miles et al. 2008) (Mujahid et al. 2008) (Singh et al. 2008)
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## Meso-level environmental factors: Schools

Topic	n	References
school cafeteria food	8	(Wolfe et al. 1994) (Duran-Tauleria et al. 1995) (Vignerova et al. 2004) (Rapp et al. 2005) (Veugelers and Fitzgerald 2005) (Whitmore Schanzenbach 2005) (Finch et al. 2006) (Ramos and Barros 2007)
food available in vending machines or through fundraising	5	(Forshee et al. 2005) (Kubik et al. 2005) (Veugelers and Fitzgerald 2005) (Anderson and Butcher 2006) (Ramos and Barros 2007)
school PE time	5	(Datar and Sturm 2004) (Sturm and Datar 2005) (Veugelers and Fitzgerald 2005) (Wardle et al. 2007) (Cleland et al. 2008)
available structured after-school activities	2	(Lumeng et al. 2006) (Cleland et al. 2008)
outdoor play equipment or gym equipment in schools	1	(Veugelers and Fitzgerald 2005)
type of care in kindergarten/day care/ after school	2	(Rapp et al. 2005) (Yee Fei 2008)

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## Policy measures

### Impact on macro-level factors

Topic	n	References
PE requirement law	1	(Cawley et al. 2007)
Smoking policy	5	(Chou et al. 2004), (Rashad et al. 2006) (Gruber and Frakes 2006) (Baum 2008) (Courtemanche 2008)
Education policy	2	(Loureiro and Nayga 2005) (Arendt 2005)
Environmental policy	2	(Loureiro and Nayga 2005) (Rashad et al. 2006)
Food market regulations	7	(Lakdawalla and Philipson 2002) (Cutler et al. 2003) (Loureiro and Nayga 2005) (Variyam and Cawley 2006) (Bleich et al. 2008) (Etilé 2008) (Schroeter et al. 2008)

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## Impact on meso-level factors

Topic	n	References
Worksite intervention	2	(Thorsteinsson et al. 1994) (Catlin et al. 2003)
After-school sports programme intervention	4	(Yin et al. 2005) (Gutin et al. 2008) (Martinez Vizcaino et al. 2008) (Weintraub et al. 2008)
School food and sports intervention	1	(Sallis et al. 2003)
Other interventions at home, at school and in the community	1	(Economos et al. 2007)

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## Impact on micro-level factors

Topic	n	References
Income support / other benefits for individuals/families	1	(Duran-Tauleria et al. 1995)
Minimum wage law (individual-level economic situation)	1	(Chen and Meltzer 2007)
School food programme (National School Food Programme, National School Lunch Programme, National School Breakfast Programme)	6	(Duran-Tauleria et al. 1995) (Melnik et al. 1998) (Jones et al. 2003) (Whitmore Schanzenbach 2005) (Millimet et al. 2008) (Schaefer et al. 2008)
Food assistance (e.g. Food Stamp Program)	15	(Gibson 2003) (Jones et al. 2003) (Gibson 2004) (Melgar-Quinonez and Kaiser 2004) (Chen et al. 2005) (Hofferth and Curtin 2005) (Gibson 2006) (Jones and Frongillo 2006) (Rose et al. 2006) (Alston et al. 2007) (Kaushal 2007) (Kim and Frongillo 2007) (Ver Ploeg et al. 2007) (Meyerhoefer and Pylypchuk 2008) (Ver Ploeg et al. 2008)
Public housing assistance (affects neighbourhood but also individual-level economic situation)	2	(Kling et al. 2004) (Fertig and Reingold 2007)

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